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J. F. KELLY, Editor

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EDITORIAL

A MESSAGE FROM THE PRESIDENT

To the Membership of the Association
of Iron & Steel Electrical Engineers.

Dear Sir:

Some twenty years ago, a handful of men, engineers, representing a small number of steel plants, undertook the problem of establishing a clearing house where operators and engineers could meet on a common ground and exchange ideas and opinions which would enable them to solve their problems and also contribute their share in the progress and development of new equipment. This clearing house became the AI&SEE and today is recognized as the engineering authority in the Iron and Steel Industry.

The steel mill problems are just as extensive today as they were twenty years ago. It is obvious that millions of capital is invested in old plants and obsolete equipment. The transition to new plants and new equipment must necessarily be slow but nevertheless these problems must be faced and the old equipment must go.

In the transactions of the AI&SEE are the engineering practices prevailing in 1907 and those now in use in 1928. These volumes with their information serve in striking and authorative fashion to indicate the lines on which future changes will be made. The AI&SEE is and should be a factor in the new developments and, therefore, we must contribute our share in the new era.

Through the proper co-ordination and functioning of all the committees and membership, it is only natural to suppose that our experiences will increase and that we will be in a better position to render a real engineering service to the Iron and Steel Industry in the changing from the old to the new.

In my capacity as President, I am charged with the appointment of National Committees and their Chairmen. No one can have the complete knowledge of our membership that is so necessary to get all of the available talent to function on these committees. With the advice and counsel of many of our officers and the membership, the appointments of national chairmen and committeemen were made with the feeling that these men were qualified to execute the duties assigned them. On the other hand, it is appreciated and fully realized that there are members who could, if they would, materially strengthen the structure of the various committees and to these members we extend an invitation to present themselves for assignments for committee work.

On page two of the September issue of your Iron and Steel Engineer are listed the various national committees and their chairmen.

Your president earnestly solicits your co-operation during the coming year and invites you to take an active part in all of your district section and national meetings. Especially do we ask your support of the district sections for the success of the national organization is dependent on the success of the district sections.

Yours very truly,

C. S. PROUDFOOT,

President.

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Symposium—Lubrication

*Steel Mill Lubrication**

By E. P. MALLISON†

(A) Introduction

THE general introduction of the electric drive has effected in recent years some very marked changes in the rolling of steel. Changes in methods of rolling have changed the power requirements, increasing the loading and mill speeds so that mill tonnages today are very much greater than they were ten and even five years ago. The art of rolling steel has usually led and seldom lagged in the advance of the iron and steel trade. From 1783, when Henry Cort obtained his patents for puddling iron and rolling it into bars, the design of machinery has steadily improved both in power and accuracy. At no period probably have these advances been so rapid as within the past five years.

(B) Purpose

The purpose of this paper is to indicate how the science of lubrication has fitted into the scheme of progress. Probably in no industry is the necessity for continuous operation of more importance; in no industry is there greater loss as a result of forced shutdown. Increase in the size of ingots rolled, the development of high speed motor driven continuous mills, and the greater competition in the steel market have further enhanced the value of reliability as well as operating economy.

Continuous operation at minimum cost per ton is the standard sought. Many forces militate against this objective, such as roll changes, short orders, furnace operation, mill breakdowns and repairs. The function of correct lubrication as a factor in maintaining continuous operation is, therefore, of great importance. The automatic features of the modern mill have substantially reduced the cost of operating labor. It is therefore desirable that the auxiliary features which serve the main purpose will assist in economy developments.

Discussion will be confined to those modern installations where lubrication of reduction gears, mill pinions and their bearings is being secured with single lubricant applied by an automatic circulation oiling system. Those members of the mill which, in our experience, can be served by a system of this sort would include the following:

(1) The Pinions. Their function is to divide the power supplied by the motor through a single shaft or spindle among the rolls and to control their direction of rotation. In the oldest form the teeth ran straight across the face, but eventually it was found that smoother operation resulted from dividing the face in two parts and staggering the teeth of the two halves. The present pinions are made with helical or "herringbone" teeth, are accurately machined and generally heat treated. This tends to materially reduce vibration inasmuch as some parts of the teeth are always in contact and transmission of the power is continuous. It also permits of much higher peripheral speeds. Pinion speeds are likely to vary from 10 to 375 r.p.m. A typical high speed pinion on a strip or skelp mill will have a P.D. of 12″ to 14″, a face width varying from 20″ to 28″. At the other extreme a typical pinion for a large blooming mill would run approximately 60″ between the necks, have a pitch diameter of 40″ with 14 teeth.

Early lubrication practice was to give the pinions an occasional dressing of pine tar, plumbago and tallow, or other mixture of grease. This practice was followed later by having the pinion housings cast in one piece so as to form an oil bath in which the bottom pinion is partly submerged. This has in turn been followed by the present practice of spraying a heavy bodied oil under pressure to the teeth at the line of mesh.

(2) Reduction Gear Drives. The present high speed continuous mills have introduced accurately cut single and double helical reduction gears in single or multiple reductions, serving one or more roll stands. The horsepower transmitted will vary from 500 to 2,500.

(3) Bearings. The pinion bearings are plain babbitt lined and are integral generally with the housings, being mounted in machined windows of the housing. The gear bearings are generally of the ring or collar oiled type and are babbitted.

(C) Definition of Correct Lubrication as Applied to Present Problem

Correct lubrication results from the complete and continuous separation of the rubbing surfaces of the gears, pinions and their bearings by an oil film of sufficient strength to resist the pressures, with minimum fluid friction. There must be arrangements for a continuous supply without waste of clean, cool lubricant of the proper quality.

Correct lubrication as related to the present problem must satisfy the following conditions:

(1) Reliability in terms of permitting full and continuous production. There must be assurance of a sufficient supply at all times of the proper lubricant to permit of normal operating temperatures of gears, pinions and their bearings. The mechanical features of the system itself should introduce no elements where breakdowns are likely to occur. A further advantage resulting from the use of a single lubricant is in the elimination of the danger of contamination of the gear lubricant with an unlike bearing lubricant, and vice versa. There is always a tendency for this transfer regardless of the care exerted by the manufacturer in sealing the bearings and equipping them with oil slingers and oil wipers and drain grooves.

The ring oiled bearings of the drives are in effect a miniature automatic circulation oiling system. Their limitations are the small volume of oil in service and inability to control the rate of feed. In bearings of large size, high speed and heavily loaded.

*Presented before Philadelphia District Section A. I. & S. E. E., February 4, 1928.

†Vacuum Oil Co., New York, N. Y.

the pumping capacity of the rings may be less than the requirements to assure normal operating temperature. The modern system of lubrication offers a means of

(a) Changing the oil automatically and continuously.

(b) Maintaining a constant level.

(c) Varying the feed to meet the operating condition.

These result in a supply of clean and cool oil in sufficient quantity to maintain a strong supporting film and also act as a coolant.

(2) Maximum Life of Equipment. With the older machinery frequent replacements were necessary and were not so expensive, but with the higher cost of new machinery, replacements are costly and shutdowns seriously interfere with production. The continuous action of supplying and withdrawing a fluid lubricating medium to and from the gears, pinions and their respective bearings, permits of the immediate removal of ore dust, mill dirt and scale and other solids which act as abrasives, producing rapid wear.

(3) Lower Operating Costs. Included in this item should be considered less consumption of power, a reduction in oiling labor and in the cost of lubrication. The rapid absorption and removal of heat by a cool fluid lubricant, together with minimum fluid resistance, produces low operating temperatures and maintains the proper relation of the machine parts. This assists materially in the reduction of frictional losses and therefore permits of high operating efficiency.

It is a well known fact that the movement of the roll necks in their bearings, the pinions and their bearings, the driving gears and bearings as well as spindles, couplings, etc., impose a very considerable frictional resistance, depending upon the design and operating conditions of the mill. Numerous tests have been run with the desire to determine exactly the power required to roll steel of various sections, and also to determine the frictional resistance of the moving parts. Reliable tests show, for instance, that the total power developed by a **reversing mill** engine is distributed about as follows:

30% used in actually deforming the steel
27% used in overcoming idle friction of the engine parts
13% used in overcoming roll journal friction
21% used in overcoming acceleration of the parts in reversing
9% used in overcoming pinion and spindle friction.

The development of roller bearings capable of sustaining the loads involved has of course materially reduced the power required in overcoming roll neck friction. On **continuous mills** the power required in overcoming pinion, gear and spindle friction runs 12 to 15 per cent of the total power delivered generally. Recent tests on modern strip mills, oil lubricated and equipped with latest refinements, indicate a power requirement about one-half that used in ordinary strip mills of corresponding sizes. An additional factor is the elimination of any undue starting torque, particularly in cold weather.

The cost of labor in attendance on a well designed modern system is very small. The requirements are periodic inspection of the various oil flow indicators, thermometers, gauges, etc.

Due to the care exercised by the manufacturer in the design of bearings as well as gear and pinion housings, the mechanical losses of oil are practically nil.

(D) Application and Handling of Lubricant

Primarily the lubricant is applied by means of a circulation oiling system. The system consists essentially of

(1) A main supply line with branches to the various elements to be lubricated.

(2) A common return line into which drains the individual returns from each element.

(3) A suitable supply or return tank to rest and cool the oil, and separate the heavy impurities and water.

(4) A means of cleaning and purifying the oil.

(5) Clean oil storage capacity.

The oil is applied to the gears under a pressure of 20 to 30 pounds per square inch by means of properly designed spray nozzles. These nozzles deliver the oil to the gears close to the line of mesh so that at the moment of contact the gear teeth are generously supplied with lubricant. The oil **to the pinions** is supplied at the top of the housing and cascaded into the engaging teeth by means of baffle plates suitably arranged. Suitable regulating devices permit of control of the oil flow and sight flow indicators permit the operator to detect at a glance the quantity of flow. Suitable return piping drains the oil from the bottom of the gear case or pinion housing into a large return tank. Supply lines and regulating sight feed oilers also furnish clean cool oil **to the bearings** and the oil is returned from the bottom of the bearing reservoir similarly to the return tank.

After the oil has done its work it should be given a short period of rest. This is for the purpose of dropping out solid impurities and water. This is accomplished in the return tank, the size of which depends of course on the volume of oil which it is necessary to circulate.

Additional cleaning is given the oil by some arrangement for by-pass purification intended to assure the thorough and complete removal of water and insoluble impurities.

A clean oil supply tank is used to store the conditioned oil and to assure a generous supply of oil at all times. This also permits the oil to cool, thus restoring its original viscosity.

(E) Lubricating Medium

The problem of selecting the proper lubricant for steel mill drives is basically composed of the following factors:

(1) It must possess sufficient body to establish a film on the working surfaces of sufficient strength to resist rupture by the unit pressures imposed. These pressures are most severe on the engaging teeth of the pinions because of the shock loads to which these parts are subjected. An examination of the power load curves on the motor drives indi-

cates this feature, in addition to which the energy given up by the revolving masses must be considered. There are variables such as draught, temperature of the material, roll condition, etc., which make it extremely difficult to calculate, even on similar mills, just what this condition of maximum loading on the pinion teeth will be. It is therefore logical to select an oil which, by its body and adhesive characteristics, offers the maximum factor of safety against film rupture.

In this connection it is very seldom found that the oils selected are too heavy to properly take care of the bearings inasmuch as the working clearances generally allowed are sufficient to accommodate these oils under working temperatures.

In addition to its function as a lubricant, the effect of continuously washing the gears and pinions with a cool fluid lubricant maintains clean contact surfaces and results in a cooling action.

(2) It must be adaptable for use in a circulation system. The circulation system involves the constant use of the same quantity of oil. It is therefore obvious that a properly selected, carefully manufactured oil will result in the greatest degree of dependability and economy.

The natural enemies of lubrication which the oil must combat are heat, air, water and solid impurities. Air and heat cause a certain amount of oxidation of the oil, forming products some of which are soluble and others insoluble. Water combines with products of oil oxidation and other foreign impurities to form emulsions in the oil. The activity of these agents is overcome by (1) the use of a high quality oil possessing maximum chemical stability, (2) provision for the removal of water and solids by heating, settling and cleaning, and (3) the reduction of soluble oxides by cooling and settling.

(F) Conclusions

The present systems which have been applied to blooming and universal mill pinions and bearings, as well as the drives, pinions and bearings of continuous mills, are the outgrowth of the demand by both the steel mill operators and equipment builders for a lubrication service which would meet modern mill practice. The last word has not by any means been said. Improvements in the design, manufacture and placement of the machine parts, as well as in roll construction, temperature control, etc., will result eventually in the use of lighter bodied oils than are used at present, with the improved economy which this involves. This practice permits of compact design, smaller gear and pinion housings, and the elimination of elaborate bearing seals and grooving.

In conclusion it might be stated that the lubrication of the modern high speed mills is of great importance, has possibilities for substantial economies and is worthy of the most careful thought and planning.

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*High Pressure Lubrication**

By F. D. STREET†

WHEN Mr. Burr kindly invited us to take part in this evening's program he suggested as a theme the subject of High Pressure Lubrication.

There are of course many phases of this subject and much has been written and said about the application and use of pressure systems.

In the development of our Safety Lubricating System the practice of safety first has been uppermost in our endeavor.

The Keystone Safety System is the out-growth of an idea of a man who for a number of years was connected with the iron industry and from its introduction in one plant more than eight years ago, has reached a point of wide recognition in all classes of industry. Quite naturally its growth in iron and steel and metal working plants has been of a larger volume.

Sometime ago one of the leading accident insurance companies broadcasted a bulletin to their field organization calling attention to this safety lubricating device. Later on one of the major automobile builders reported remarkable reduction in accident cases in the press department of their plant. Before the centrally controlled lubricating system was adopted there were from four to five accident cases reported every week. Six months after the department was equipped with the Safety Lubricating System a check-up was made and it was found that not a single accident attributable to lubrication hazard had been reported to the plant hospital.

Statistics from two leading industrial States (which may be taken as a fair average) covering the period of the year 1923, show a total of 12,191 machinery accidents, of which more than 1,000 occurred while machinery was being oiled. These statistics show that 50% of all machinery accidents occurred while starting or stopping a machine unit.

The conclusion is reached, therefore, that while only about 8% of the accidents are listed specifically under the "while oiling" classification, a much larger proportion, even as high as 25% of the total, could and should be charged against the item of lubrication.

In a Philadelphia floor covering plant the inlaid machine driving mechanism is located under the machine, and to reach this machinery it is necessary to pass through a narrow concrete subway to a small room where the driving mechanism is located. Clearances are very close—some of the drives are geared and others are belted and it has happened that while passing these close clearances oilers have been caught in the moving parts and seriously injured. I believe in one instance a man died as a result of injuries sustained.

Picture the present method—a lubricator is fastened to the wall out in the main passage and pipe

*Presented before Philadelphia District Section A. I. & S. E. E., February 4, 1928.

†Keystone Lubricating Co., Philadelphia, Pa.

lines lead into these various bearings. The oiler simply turns the wheel of the lubricator and all of the bearings are served. Positively no danger to be encountered now.

The lubrication of outside cranes is very hazardous, especially in winter time, what with icy foot walks, etc. A lubricating system of this kind is a sure preventative of accidents of this kind.

Based upon the fact that safety first principles are being studied and practiced very generally throughout industries we have undertaken to produce a motion picture which would show the safety principles involved in the application of lubricant through the medium of the centrally controlled lubricating system.

Through the kindness of the Packard Motor Car Co., Detroit, the Sharon Steel Hoop Co., Lowellville, Ohio, (I might mention here that Mr. Richard Jones of this company, a member of your organization, very kindly assisted us in procuring the pictures at that plant) and the Aldrich Pump Co., Allentown, Pa., we have succeeded in obtaining some interesting pictures showing the operation of drawing and stamping presses used in forming automobile body parts and the operation of open hearth cranes in pouring metal into Ingot moulds, together with other units of machinery equipped with this safety system.

You will be interested to observe the convenience of operation of the lubricator and the fact that the operator is kept out of the path of danger and is able to force the lubricant to all parts of the machine from a safe and convenient position.

There has been a great deal of discussion here this evening on the use of various kinds of lubricants and methods of application. Before starting the picture I would like to bring to your attention an instance which offers outstanding proof of the importance of application, be the lubricant oil or grease.

In one of the eastern foundries of a large electrical manufacturing company five cranes were used to handle the production of the plant. About four years ago one crane was equipped with this lubricating system. In due course the second crane was equipped and subsequently four cranes had been equipped. By this time the company had reached the conclusion that the fifth crane was not needed in the foundry and it was dismantled and transferred to another department where an additional crane was required. This reduction in equipment was made possible through the fact that lost time through repairs had been reduced to such a remarkable extent that the four cranes were able to handle the production of the foundry.

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*Centrifugal Purification of Oil**

By HENRY T. MOORE†

VERY few who are not associated with, or actively engaged in, the Centrifugal business, realize the number of commercial applications now in use.

The successful applications of Centrifugal Force now in daily use are saving and earning thousands of dollars every working day in the year. The Chemical Industry has a number of applications: Paint and Varnish Makers find Centrifugal Force one of their best tools for producing high grade products.

One of the important steps in the manufatcure of Insulin is a Centrifugal Process. Printers find Centrifugal Machines will clean their ink quicker, easier and better than any other method.

But nowhere do we find more interesting and varied uses for Centrifugal Force than with the manufacturer and user of petroleum products. The applications of the Centrifuge in the petroleum field cover a wide range, from the manufacture of bright stocks and the recovery of bottom settlings in the refineries, to the continuous purification of naphtha for the dry cleaner who cleans your clothes. Between these extremes are many of the applications which will be discussed here.

I will endeavor to explain the more important processes which have been developed for Centrifugal Purification of Petroleum Products. We may classify this work in three groups:

1—Insulating Oils.
2—Lubricating Oils.
3—Fuel Oils.

But before going into detailed explanations of the various processes, I think it would be well to consider briefly the construction and principles of the Sharples Super Centrifuge, which is an integral and most important part of each process.

THE SUPER CENTRIFUGE

The Super Centrifuge, consists of a hollow rotor called the bowl, connected by a coupling nut to a spindle, which is suspended from a ball bearing assembly. Surrounding the bearing is a pulley driven by a belt from a motor mounted on a bracket on the back of the frame. The belt tension is maintained by an idler pulley and counterweight. Inside the bowl is a three-wing device, whose purpose is to keep the liquid passing through the rotor from swirling. The lower end of the bowl is entered in a drag bushing mounted in what is called the drag assembly.

Liquid is fed through a short feed tube at the bottom and jets into the bowl, passing up through it and discharging from tinned steel covers at the top. The dirt or sludge and water are separated by

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†Lubricating Engr., Sharples Specialty Company, Philadelphia, Pa.

centrifugal force from the oil as it passes through the bowl.

Centrifugal force is exactly comparable with gravitational force except in the intensity of its action. Centrifugal force can accomplish results impossible with gravity, but nothing that a correspondingly magnified gravitational force could not do. The fact that it is necessary to revolve a body of liquid in order to develop centrifugal force within it frequently obscures the fact that an action similar to that in a quiescent body of liquid is taking place.

Centrifugal force in terms of gravity varies as the diameter of the bowl, and as the square of the R.P.M. It is shown by the formula—

$$F \text{ (times gravity)} \quad .0000284\ NR^2$$

where N inner radius of the bowl in inches.
R=R.P.M.

The centrifugal force generated in the commercial Super Centrifuge bowls varies from 13,000 to 15,000 times the force of gravity. The laboratory model develops a force 40,000 times that of gravity.

When a mixture of oil, water and dirt stands undisturbed, gravity will tend to effect a separation into an upper layer of oil, an intermediate layer of water, and a lower layer of the solid. When the mixture is placed in a revolving centrifugal bowl, the effect of gravity is negligible in comparison with that of centrifugal force, which acts at right angles to the axis of rotation of the bowl. The mixture tends to separate into a layer of solid at the periphery of the bowl, an intermediate layer of water, and a layer of oil floating on the inner surface of the water. The discharge holes of the bowl top are so provisioned that water can be drawn off from the periphery of the bowl and discharged into one cover. The oil is drawn from the surface of the water and discharged into the other cover. The solids deposit against the wall of the bowl, to be cleaned out at the end of the run.

Our Centrifuge may be equipped with either a separator or clarifier bowl. When solid alone is to be removed from a liquid the clarifier bowl is used. This bowl has but one set of outlet ports from which the liquid discharges continuously during operation. Solids deposit in the bowl.

The separator bowl has two sets of outlet ports so arranged that both liquids in a mixture discharge separately and continuously. Such a bowl is adjustable to handle two-liquid mixtures of any specific gravity differences.

The separator bowl may be employed for clarification by the use of a sleeve, which is slipped over the neck and closes off the heavy liquid discharge ports.

Our Centrifuge is manufactured in two distinct types; the open type machine, and the Presurtite or enclosed gas tight machine. The enclosed machine is used in place of the open type wherever it is necessary to prevent escape of vapors or gases from the materials being centrifuged. If there is pressure set up by such escaping gases, or if it is necessary to set up a pressure or vacuum during centrifugation, the gas tight machine is used. The gas tight is so installed that pipe connections for liquids discharged from the machine are placed permanently and no uncoupling is required when the covers and bowl are removed from the frame. The Presurtite is also useful where liquids must be kept from contact with air, in which case the air may be exhausted from the frame or replaced by another gas.

PURIFICATION OF INSULATING OILS

The Centrifugal Purification of Insulating Oils is interesting in that it brings out the very important fact that it is not the kind of oil, grade or weight, which determine the proper method of centrifugal purification, as much as the use to which the oil is put.

The large electrical manufacturing companies are furnishing the trade a universal oil for use in both transformers and switches.

The purification of this oil, after use in transformers, is an entirely different problem from its purification after use in a circuit breaker or switch.

Purification of Transformer Oil

The Centrifugal Treatment of Transformer Oil involves the removal of water, sludges formed by decomposition of the oil, particles from deteriorated insulating materials and similar solids that are introduced during the handling and use of the oil. In removing these foreign materials, the oil is restored to the high dielectric strength necessary for the proper operation of transformers.

The process consists briefly in heating the oil to about 50 deg. C., feeding it to the machine at a rate of 400-600 or more gallons per hour on the largest unit and returning the purified oil to the transformer. With the rare exception of wet and dirty oils that have very low dielectrics, one pass through the machine is sufficient to secure a dielectric above the required value of 22.0 kv. Usually dielectrics of centrifuged oil after one pass range from 30-40 kv. and above.

The purification of transformer oil is a very exacting problem. Minute traces of solid material and sludges, particularly in the presence of very slight traces of water, exert a remarkable effect in lowering dielectric strength. High centrifugal force removes the impurities commonly encountered rapidly and effectively so that the oil is restored to a dielectric strength that will safely withstand the enormous voltages carried by the transformer.

Our Centrifuge has been portably mounted for this service. The unit carries heaters, pumps, the Centrifuge and other auxiliary equipment required in a duty where speed and efficiency of operation to restore or improve service is a necessity.

Purification of Circuit Breaker Oil

Although it is common practice to use exactly the same kind of oil in either switch or transformer service, the problems presented in the purification of such oil after use are widely different. The bulk of the transformer oil can be restored to satisfactory condition for re-use by the simple centrifugation described above. Switch or circuit breaker oil generally requires a combined centrifugal chemical treatment for purification.

The used oil contains carbon that is not removed by centrifugal force alone under commercial conditions. It contains acid products of deterioration and has an impaired resistance to emulsification with water. When the contamination and impairment

have progressed too far, the oil must be processed and no method has proven quite as satisfactory as the following.

The oil is mixed with a dilute sodium silicate solution, the mixture heated and then separated. This operation removes carbon and reduces the acid value of the oil to a sufficiently low figure. The resistance to emulsification is improved and the oil given a final clarification by treating with a small amount of decolorizing earth, heating and centrifuging

PURIFICATION OF LUBRICATING OILS IN STEEL MILLS

Lubricating oils of all kinds are purified for reuse with the Centrifuge. The method of making an installation for the purification of such oils, and the treatment to which the oil is subjected before purification, varies somewhat with the service in which the oil has been used. The most important differentiation, however, between lubricating oil purification methods is in the batch system as opposed to the continuous system of purification.

Batch System of Purification

The batch system is useful in purification of oil in small quantities from units where sight feed, or mechanical force feed lubricators supply relatively small quantities of oil to the lubricated parts, the oil from these parts being collected. Before the economy of oil purification was fully appreciated, it was common practice to discard such oil. It is now considered good practice to collect the oil, wait until a sufficient volume has accumulated, and then to reclaim it. In many cases, the only treatment necessary is a simple centrifugation assisted by heating to lower viscosity, and hence increase the efficiency of the centrifugal treatment. In other cases, where the oil is badly contaminated with carbon, sludges, and other impurities, treatment of the oil before centrifugation is sometimes necessary. To remove carbon, heating and agitating the oil with dilute alkaline solutions is very effective. In other

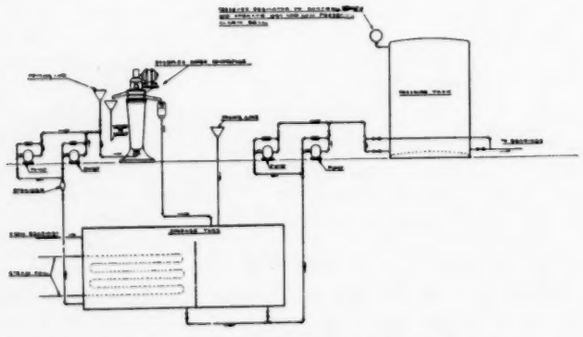

FIG. 1—Lubricating Oil System for Plate, Bar, or Skelp Mills.

cases, a treatment of the oil with water in a tank, or, introducing the oil simultaneously with water into the centrifuge is a satisfactory means for obtaining sufficient purification.

Batch treatment is frequently practiced to clean up accumulations of used oil when the centrifuge is first put in operation on large engines. Frequently these accumulations are sufficient to return oil worth as much as the investment in the centrifugal equipment. After the installation is made and accumulations cleaned up, continuous purification suffices to keep the oil clean and draining becomes unnecessary.

Continuous Purification

Where steel mills, or other units, have oil reservoirs from which the oil is pumped to lubricated parts, and to which the oil drains after it has performed its function of lubrication, continuous purification of the oil is recommended. With large units in which the rate of flow of oil through the bearings is usually at a high rate, the arrangement shown in Figure 1 shows a typical layout such as is used for the lubricating oil system for plate, bar, billet or skelp mills and other similar equipment in steel mills. Under such a plan the circulation of the oil to the lubricated unit is entirely separate from the circulation of the oil through the purification equipment and either operation can go on while the other is not running.

Turbine Lubricating Oil

Figure 2 is illustrative of the method employed to draw oil from the oil reservoir of a turbine for purification. In this way the oil from the very bottom of the sump, where the oil is dirtiest, is

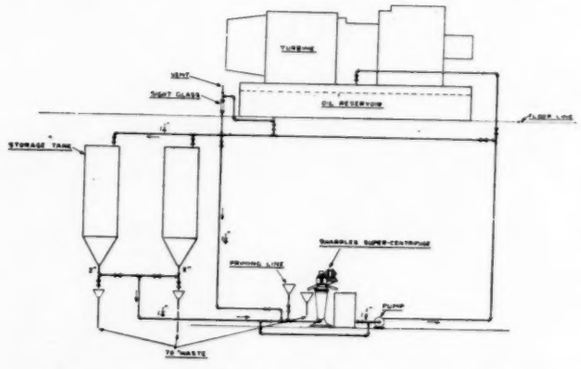

FIG. 2—Lubricating Oil System for Turbine.

taken to the centrifuge. Yet the draw-off is so arranged that the oil level never falls below a definite point and there is no danger of failure of the oil supply.

The virtue of continuous purification is the maintenance of a higher average degree of purity of lubricating oil in the system, than is possible under a system which depends upon makeup, sweetening, or intermittent oil change to keep the oil in proper condition to perform its important service.

Diesel Lubricating Oil Purification

The value of lubricating oil purification has been more generally recognized and centrifugals more widely adopted in connection with Diesel engines than for most other uses. The service to which lubricating oil is put in the Diesel is so exacting and contamination so severe that a positive, rapid and effective method of purification is of first importance. Centrifugal methods have met the need of this service much more effectively than competitive devices. Diesel lubricating oil is subject to contamination from various sources. Although the quantity of contaminants depends very largely upon the de-

sign of each particular engine, as well as operating conditions of the engine, the general contaminating materials that cause trouble are: 1. Carbon resulting from incomplete combustion of the fuel in the cylinders, which carbon finds its way into the oil. 2. Water from condensation of atmospheric moisture in the crankcase and from leaks which may occur in cooling coils or in the cooling system of the engine. 3. Dirt and dust of various sorts entering the crankcase from the air and with lubricating oil and unburned fuel from the cylinders. 4. Metallic particles resulting from wear of parts in the engine. 5. Sand from cast parts of the engine. 6. Thick oily sludges resulting from decomposition of the oil under the high temperatures of engine operation. Of course, all of the above impurities are not necessarily present in every case.

Sand, dirt and metal particles cause abrasion of lubricated parts, water may replace oil in bearings and hence cause wiping, or bearing seizure. Carbon and oil sludges, together with other solid materials form deposits which interfere with the operation of oil pumps and clog oil lines and passages so that insufficient lubricant is received at lubricated point.

Experience has demonstrated that properly purified oil may be used almost indefinitely, and that it is not necessary to discard the contents of an engine crankcase at intervals. Hence the plant that uses proper purification methods may greatly reduce the amount of lubricating oil purchased, buying only enough to replace the oil that is actually burned, lost or destroyed in engine operation. Furthermore with a good purification system wear on lubricated parts is reduced so that bearing adjustments and repairs are kept at a minimum.

Purification of Fuel for Diesels

The use of the cheaper grade of fuel oils instead of the more expensive Diesel fuels has caused widespread recognition of the usefulness of the centrifuge for purification. The chief difficulties encountered in operation with low grade fuels are caused by water, solid matter and ash-forming constituents. Centrifugal treatment removes the first two almost completely, only infinitely small particles remaining, and materially reduces the last. Even the high grade fuels contain surprising quantities of impurities that the centrifuge will remove. The effect in either case is to improve operation and greatly reduce wear of certain of the engine parts.

The Diesel depends to so great an extent for smoothness of operation and fuel efficiency on accurately operating fuel pumps, fuel valves and atomizers that every precaution should be taken to prevent interference with the operation of such parts.

This is a subject that has apparently received very little attention from Diesel builders and operators. Yet what benefit is there in the exact machining of fuel pumps, valves and nozzles to thousandths of an inch in accurate orientation ports and valves in cylinder walls, and alignment of atomizers, if such parts are allowed to become clogged, worn and interfered with by impurities in fuel oil? A great deal of study has been devoted by some builders to directing the fuel into the cylinders in such fashion as to permit as near perfect distribution of fuel through the fuel chamber as possible and to secure an even mixture of fuel with air in the cylinder. When solids accumulate in atomizers and fuel valves much of the value of careful engine design may be lost.

It is not hard to appreciate that water unevenly distributed in oil will cause erratic firing or even misfires, and that sand, rust, and other dirt injected in cylinders with the fuel will cause wear on pistons and liners and even on bearings if the unburned oil from the cylinders enters the crankcase oil. The troubles from solids, such as the above and from fibres, lint and carbon that collect in the parts through which the oil passes to the engine can be quite as great.

The following figures cover a 30 day test run made by an engine builder to clean fuel used in testing a 3900 H.P. engine for the U. S. Shipping Board. Two Presurtite machines running one at a time cleaned over 140,000 gallons of fuel oil of 25 deg. Be. gravity in 30 days, removing 1,478 lbs. of "muck" that would otherwise have entered the engine fuel system. An analysis of the material removed is given below.

Constituents	Percentages	Total Weight Removed
Water	27.20	402 lbs.
Oil (Petroleum Ether Extract)	41.40	608 lbs.
Asphaltenes (Carbon Bisulphide Extract)	13.17	195 lbs.
Carbon Fibre, etc. (Combustible Residue)	9.08	134 lbs.
Ash (Non-Combustible Residue)	9.41	139 lbs.
Total	100.00	1478 lbs.

Oil of this gravity is ordinarily considered relatively clean. Such results over a short test period might indicate an unfair sample of oil had been secured. Over a thirty day test run, however, there can be little doubt on this score and the test gives a reasonable indication of the results that may be expected on commercial grades of fuel oil.

All of the above constituents of the "muck," excepting oil, may be expected to interfere with proper economical engine operation. The Analysis clearly shows the protection given to cylinder liners, pistons, atomizers, fuel pumps and valves by centrifugal purification of the fuel.

Examination of the engine at the end of the above test showed that fuel strainers, pumps, atomizers and valves were free of obstruction and of wear and that cylinder liners and pistons were unscored by abrasive material.

The Presurtite Centrifuge finds one of its ideal applications on fuel where it is necessary to heat near to or above the flash point of the oil for proper purification. It absolutely prevents escape of the dangerous vapors from the oil into the air. Heavy oils particularly require heating to facilitate centrifugation.

To illustrate the advantage in heating the heavy fuels, an example of tests run on a 16 deg. Be. Bunker C oil with a flash of 150 deg. F., is interesting. At 140 deg. F. the oil had a viscosity of 16.3 deg. Engler. Heated to 170 deg. F. the viscosity was reduced to 8.0 deg. Engler. Elevating the temperature by 30 deg. F. above that at which the oil could be handled in the open centrifugal

reduced the viscosity of the oil by one-half, making it possible to double the efficiency of the centrifuging operation.

I have used several illustrations of oil purification methods that may seem irrelevant to a meeting not concerned chiefly with the Diesel engine. My aim has been to show that the longest and most efficient service is secured from petroleum oils only through the application of sound purification methods. Everyone recognizes the value of selecting oil under exacting specifications drawn to meet the needs of each particular unit using oil. Yet relatively small quantities of impurities introduced here and there in the handling and use of the oil may nullify much of the value of discriminating purchases. Each use of oil presents a somewhat different problem, requiring study on the part of centrifugal builders for the adaptation of their processes and equipments. That they have kept pace with the needs of the users of petroleum products is shown by the general acceptance of the centrifuge for oil purification.

DISCUSSION

George J. Walz, Chairman*: Gentlemen: Twenty-two years ago, one of the oldest and most progressive electrical manufacturers decided to put on the market the first Steel Mill Type D.C. Motor, designed primarily to meet the exceptionally severe punishment and abuse of Steel Plant Service. Their first move toward bringing out this entirely new design, was to obtain the advice of the best and most experienced Steel Plant Electrical Operating Engineers, this advice being extensively utilized throughout their design. When the motor did come out, it was indeed a mighty fine product, just bristling all over with a lot of commendable features, such as fireproof insulation throughout, strap copper, impregnated windings, extra heavy shafts and cast steel frames, commutating characteristics so fine, that it was practically impossible to make the commutator spark, a construction permitting the changing of the shaft, without disturbing the armature coils or commutator, etc. These motors appeared so exceptionally promising that the Steel Plant with which I am connected began to order them in large quantities almost as soon as they were announced, equipping a large new Open Hearth with them throughout, and making them the standard D.C. Mill motors for the plant.

But this splendid motor, I am sorry to say, was not a success, as it was first brought out, for presently the armatures began to come into our repair shop, invariably with large holes burned in the commutators, so fast, that we found it almost impossible to keep them in operation. It took some time to find out the cause of this trouble, but when we did, it was nothing else but oil escaping from the bearings and soaking the commutator bar and V-ring Mica insulation, and as soon as this oil leakage was checked, most of our trouble with these motors stopped.

We had four of these early motors equipped with sleeve bearings in a 75 H.P. size, driving the side guards of a 44" Blooming Mill, the armatures in which only lasted an average of 7 or 8 weeks. After we put grease lubricated roller bearings in these same motors, doing the very same work, the average life of the armature was increased to 8 or 9 months, merely because it was then no longer possible for the commutators and the windings to become oil soaked.

About 1922 the Motor Committee of the A. I. & S. E. E. sent out a set of questionaires to the electrical engineers of the twenty-five largest steel plants in the country to try to determine just what was the most prevalent cause of motor failures. When these questionaires were returned they showed that 53% of the A.C. Motor failures, and 62% of the D.C. Motor failures were caused, directly or indirectly, by the bearings, due to either oil leaking from the bearings into the windings or commutators, or due to the bearings coming down and allowing the bands to come off the armatures, etc.

Now all these considerations some time ago exploded the old time point of view that a bearing or the lubrication feature of a motor is a minor consideration. It is nothing of the sort. It is one of the most important things about a motor, and it is particularly important to the steel mill electrical engineers, who are trying to keep those motors in operation.

On the strength of all this, the Philadelphia Section decided to hold a lubrication meeting; hence this series of three papers this evening, and through which we are going to try to keep in touch with the improvements that have been lately made in modern methods of lubricating motors.

George Pfeffer*: I would like to ask the gentleman a question. What becomes of the dirt? Is it necessary to take the machine apart each time you wish to remove the dirt or does the dirt pass out of the machine through some opening?

H. T. Moore: The dirty oil is fed in through those feed pipes into the bottom of the bowl. This bowl is rotating and generating a force at the speed we operate of 13,000 times the force of gravity. That causes a complete separation of the dirt, water and oil. The dirt in this bowl will form just at this black line here (indicating). That heavy line here is the dirt, and it will gradually move over here until such time as the bowl is ready to clean. When the bowl is ready to clean, disconnect this connection here (indicating) and remove the covers. The bowl, then, on its flexible bearing on the bottom will move over on its side and be raised right out of the machine. This bowl bottom is removed, and all that is necessary is to take out the dirt. Taking the dirt out is like taking the dirt out of the inside of a pipe. It is a very easy job to remove the dirt. In addition to that there is a three-winged device that goes up inside of the bowl. It does not go all the way to the bottom. The purpose of that device is, it rotates with the bowl and brings the oil up to the same speed as the bowl. As we bring that three-wing device out we simply turn it around, and that wipes the dirt off of the bowl side on the three-wing device and we can wipe it off the three-wing device. The average time to clean a bowl is fifteen minutes, depending on the kind of dirt in the bowl. After the bowl is clean it is slipped back in the frame, the covers are slid on again, and it is ready to operate.

*Asst. Elec. Supt., Bethlehem Steel Co., Steelton, Pa.

*Chief Elec., Florence Pipe Foundry and Machine Co., Florence, N. J.

There is another feature of this machine which I think is very interesting. When the machine is slowed up the centrifugal force stops working on the oil and water, and when the bowl is about still the water will start to flow back to this nozzle down in the frame, where it is allowed to run out. When you take the bowl out of the machine there is nothing left in it except solid materials which you have to remove manually.

Chas. E. Carpenter*: I was wondering if I, perhaps, may be excused for having an opinion, inasmuch as I am interested in the sale of lubricating oil and this machine is to reduce the sale of lubricating oil. I think it is far better for me to confess on the start of my prejudice, rather than have you gentlemen suspect I have some surreptitious idea in keeping quiet.

This machine is, in my lay opinion—for I am not an engineer—an intensified use of the law of gravitation; but I do not think you take into consideration that you are dealing with a very peculiar material when you deal with a petroleum derirative. For instance, when you take water, and distill it, you still have water; and if the prohibition officers do not arrest you, and you distill alcohol, you have alcohol; but if you take a petroleum derivative, and put it in an apparatus, the very first yield from that still is entirely different from the composite contents of the still. You cannot put a petroleum derivative in a centrifugal machine without taking out of that petroleum derivative something more than the dirt.

Take a crude illustration. Take a four ounce bottle of motor oil and keep it in the dark. There is no perceptible difference in the appearance of that motor oil. But put the same oil in the window, and subject it to the rays of the sunlight, and there immediately deposits, in the course of time, a sludge in the bottom of that bottle. That sludge is the solid matter which is held in solution by the soluble portion of the petroleum derivative. That sludge matter supplies to that lubricant its film strength.

The lecturer has very truly said this centrifugal machine is used in the clarification or decolorization manufacture of what we call light stocks, which are petroleum. The best of motor oils—the bulk of motor oils are made by taking this heavy light stock and dissolving it in a petroleum distillate. The light stock is a residium, or that which remains in the still. Now you cannot take a used lubricating oil and make it a first class oil by putting it through a filter or any machine known, because in so doing you must take out of that oil that which gives to that oil its film strength. It cannot be done.

I have nothing but the highest compliment to pay for this machine. It is doing wonderful work. But the usefulness of a machine is understanding not only its merits but its demerits. The user of a fleet of trucks cannot take the used oil after it has undergone the mechanical service of being ground under very high temperatures, temperatures which run 600° to 700° or more, and revivify that oil by centrifugal purification because it breaks down the film strength and does not give the same service; and if any man puts in a centrifugal machine for the purpose of purifying such broken down oil the same as he would purify alcohol or water, the film strength having been broken down, the result is that you have something which does not lubricate. Paraffine has no lubrication film of any material strength, but is held in solution by a solvent.

This machine must be used intelligently. It must be used carefully. You must not have the idea the longer you use it on an oil the better the results, because the longer you keep the oil under the process the more certain you are to take out the paraffine or whatever it is that supplies the real strength.

Now so far as that great bugaboo is concerned, the dilution of lubricating oils in the crank case by gasoline, I want to call your attention to the fact that most of the airplane makers depend entirely on their practice of dissolving the motor oil in gasoline in the proportions of 1 to 40. If we get high class lubrication by a dilution of the lubricants of forty to one, how can you figure that a dilution of three to five per cent is going to materially injure one or the other of lubricating oils. I have never seen a test which has proved that the coefficient of friction has materially increased because of that dilution.

Two engineers of the Standard Oil Company of Indiana have said it would improve most oils if you put a little gasoline into the crankcase, and I am inclined to agree with them.

H. T. Moore: I have been very much interested in what has been said, but the tests that have been run by our government have shown that there is practically no wear out to oil; that is, if you see any oil worn out, they do not know when it was or when it occurred. If you have a suitable oil on a job, and feed it through the engine, you will get good lubrication, provided you do not allow to enter into that film, abrasive materials.

Now there is another thing I want to bring to your attention, that the Sharples machine or any other centrifugal has no chemical effect we have been able to find out on oil. The most delicate oil sold today, under the closest specifications, and most rigid inspection, is insulating oil. We have taken insulating oil, ten gallons of it, hooked it up to the Sharples machine, circulated and re-circulated that at the rate of fifty times an hour, for two or three or four weeks, without being able to find in the most delicate chemical test any change at all in the oil. All we have tried to do with our machine, or expect to do, cannot affect anything from a chemical standpoint.

It is possible to clarify oil by building a tall tank and let it stand long enough to get clean oil off the top. In this type of machine we do the same thing, except we have a centrifugal force there which enables us to make that separation much more quickly, instead of having big tanks, which take up too much space.

R. F. Gale*: I have not much to add to the discussion of this particular subject, except to emphasize the necessity of lubrication.

It took about all the concentrated effort I could command, all the educational effort I could think of, to emphasize the importance of lubrication. When times get slack, which they unfortunately do

*President, E. F. Houghton & Co., Philadelphia, Pa.

*Plant Engr., The Midvale Company, Nicetown, Philadelphia, Pa.

in a steel mill, the force has to be reduced. In this event the foreman favors repairmen, and used to immediately lay off the oilers, and expect repairmen to do their own oiling. With this procedure the lubrication is sure to be neglected. However, for the last six years, after continual argument, the oilers are kept, and the reduction made in ranks of the repairmen. While the repairmen do not like oiling, they do do it, but surely not so thoroughly as the regular oilers. When the repairmen come to the realization that a little more oil will save a lot of back-breaking work, the bearings will be properly lubricated, and not before.

Today the lubrication in a steel mill has gotten to be one of the really big problems. One foreman told me, "I hope I throw away $800 worth of grease and oil every year. I'd rather throw away $800 worth than run the risk of saving $10." I rather agreed with him.

G. J. Walz: While I have not had any extensive experience with lubricating oil that has passed through these centrifuges Mr. Moore has described, we do have two of them at our plant. We use one exclusively for transformer oil, and have had mighty good success with it. The other one is used to purify the lubricating oil on a main roll reversing drive, and appears to be functioning in an entirely satisfactory manner.

Mr. Carpenter, I do not believe, had reference in his remarks to transformer oil.

C. E. Carpenter: No, I did not. You could not, in my opinion, use the centrifugal to better advantage; it is a God-send to transformer oil.

R. F. Gale: Referring to the pictures shown by Mr. Tyler. Assume a system holding 600 gallons of oil, and several elements are operating on that system. The purification is done by gravity. Under these conditions the mill man thinks he should change the oil periodically, say once in six months. If a purifying machine is installed, how much longer will that same oil give perfect lubrication? I would like to get a sort of a rule-of-thumb idea as to how much longer a purifying system will permit the use of the same. One might think from the papers here tonight that it might last indefinitely, and all that has to be done is to make up the shrinkage. I would like to know whether it would jump from six months to five years, or six months to two years, or six months to twenty years.

L. P. Tyler*: That is a very difficult question to answer. In the first place every operating condition I have seen on these mills is different. I know of some mills that have been in operation for a year, approximately, with the cleaning equipment and circulation system. A particular mill system I have in mind holds 8,000 gallons of oil. The only make-up that has been added to that system has been some oil that was lost from some bearings that were not properly set up. There has been a certain amount of sludge which has been withdrawn, but I would say altogether that that would not necessitate a barrel of oil. That system is singularly free from water. The edger rolls and drives are overhead. Another system I have in mind has taken up to the present time more make-up than is really desirable. That is due to leakage to some extent, to grease from bearings getting into the oil, also water getting into the oil, and a certain amount of mill scales.

I frankly confess I do not know how long the oil will last under the different conditions you are liable to meet, because from the mills I have seen each one has an individual operating condition. By that I mean the entrance of water, scale and grease in different proportions. I think these systems have not been in service long enough so that our data on that item is what I would call absolutely definite.

R. F. Gale: Maybe I did not make myself clear. The example I had in mind was a turbine in the Power House. This is considered a clean place. It has been the practice, we will say, at this particular turbine application, to take the oil out entirely every twelve months and replace it with new oil. The oil removed might be used for some lesser operation possibly after clarifying. If the purification apparatus is so wonderfully good, how long is it going to take to pay for itself. One cannot expect to get a thousand dollars from a Management without a very definite reason, preferably in figures.

L. P. Tyler: We are working now, Mr. Gale, with figures which will give us a representative idea of the cost of lubrication of steel mill systems. There are one or two systems I know of that have been in operation three years. (I will ask Mr. Mallinson to check me on this.) In neither of those systems has the main body of oil been removed.

E. P. Mallinson*: It is the same oil.

R. F. Gale: You have added to it?

E. P. Mallinson: Yes.

L. P. Tyler: The cost of lubrication per ton of steel rolled on those mills is how much, Mr. Mallinson?

E. P. Mallinson: 1 2/3 cents.

L. P. Tyler: That to my mind indicates that you have possibilities for very long service in the oil, provided you remove the impurities and the water periodically. As I said before, these systems have not been in service long enough so that we have an accurate range of data to figure on as to the ultimate life in the oil. I personally have not seen any of the systems I have had to do with where the main body of the oil has yet been removed, or where it has been necessary to remove the main body of the oil. On this system I showed you in connection with this blooming mill the main body of the oil is still in service. The make-up conditions are quite variable. A good design permits of longer service or a less make-up than where you have a large proportion of grease and water infiltration.

C. E. Carpenter: It is human nature to worry about the day you are going to die, but if you have the right dope on the situation you commence to die the day you were born. We are in a dying process all our lives, and the very moment you put a lubricant into one of those systems it starts to die; and I wish you men from Nicetown would not add all your economies on the poor oil man. We need the money.

This system is not put in to save you oil so much; it is to save you coal and air, giving you a cooling system as that oil is cleaned and these

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*Vacuum Oil Company, New York, N. Y.

abrasive and foreign parts are taken out. The water that goes through is not such as you would like to drink, it is all full of oil; each one of those little marks is a film of oil, and you are constantly and continually reducing that oil. Your oil starts to deteriorate the moment it goes through that process.

You ask the amount of economy of the oil. The cost of the lubrication, in proportion to the cost of your entire system, is infinitesimal compared to the cost of your wear and tear and people, and a lot of other things. You engineers know that. You continue adding oil, and you keep on putting in fresh oil. Now and then there is a leak, and half of the oil gets out. That is our game.

The question you want answered is, Can you save the cost of the installation of this system? Can you go to your people and say, I can install a thousand dollar system and save a thousand dollars worth of oil? No. You know pure oil, and good oil takes away the abrasiveness, reduces the friction, saves you fuel, saves you repairs and everything else, and in your mill a thousand dollars is not and should not be compared with these results.

J. R. Adams*: I came here seeking information, not knowing much about the subject. I cannot reconcile the statements made by the last speaker to the statements made by the first speaker. The first speaker states his machine removed carbon produced in the use of the oil. Now if the oil had not been heated to a high temperature, where does the carbon come from? If the oil is breaking down, how can it be used indefinitely? It is continuously deteriorating. We know most of these lubricants are hydrocarbonates and they will break down under temperature.

I would like to ask the first speaker if in the case of the motor oils they have investigated the point of whether the reclaimed oil has the same characteristics as the new oil, because I think that might throw some light on the subject as to whether it was the same or not.

H. T. Moore: I said the removal of that carbon and the water brought back its dielectric strength and color, but there were certain impurities still in that oil which were produced by the heat. Later we removed them by an application of clay. I think that will answer as far as removal of carbon is concerned.

J. R. Adams: No. You stated carbon was removed from transformers, which I do not refer to at all, but in lubricating systems.

H. T. Moore: The first step in that process removes the carbon. The second step we have is to get rid of the dilution. Our practice is not to remove all the dilution. The reason for this is more commercial than anything else. We find dilution in the crankcase reaches a given amount very shortly after oil is put in use.

J. R. Adams: Do you actually get carbon out of oil being used in a mill?

H. T. Moore: While you think right at the present time that oil is not subjected to a high temperature, when you come to think of two gears slamming together you have got a spot that may be awfully hot.

*Supt., Heat Treating Plant, Midvale Steel Company, Nicetown, Philadelphia, Pa.

J. R. Adams: All right. As soon as you produce carbon you have broken down your oil and are getting something else.

L. P. Tyler: I would like to say in regard to oil in the circulating systems, while I am not a chemist, we have had many of these oils analyzed and we find no pure carbon as such, but we do find, under heat and in contact with the air, that oxygen will oxidize the petroleum hydrocarbons, just the same as a polished steel surface. Now if you would take the surface of a piece of steel and scrape off the oxide, you would perform the same thing as if you would take the oxides in the oil and drop them out of the system. Some of these oxides are insoluble and with water and mill dirt drop down in the form of a sludge. There are other oxides, a chemical combination of hydrocarbon and oxygen, which are insoluble at operating temperature and which drop down only after the oil is cooled.

J. R. Adams: Aren't there also compounds which would be soluble and would lower the lubricating value of the oil?

L. P. Tyler: I do not think they will lower the lubricating value of the oil. We have no evidence to tell us that such is the case; in fact our people believe those soluble oxides assist to a certain extent in lubrication. They of course are not desirable in a circulating system, but they do not interfere with the actual lubricating.

J. R. Adams: There is just one more question I would like to ask. There are many places in a steel mill that ought to be lubricated. You have spoken several times during your talk of cold rollers for steel mills. From my observation the lubrication is as poor as it could possibly be, yet I cannot conceive of a lubrication being used on this. I also would like to hear an expression of opinion as to the merits of common block greases. I have a suspicion that a good many common block greases are sold on their weight. I know some of them are not barium sulphate, but they are rather a heavy compound. A great many of the oil companies are selling them to the steel man as a lubricant.

L. P. Tyler: I want to correct the impression that the circulation system I referred to covered the roll necks. It does not. They should be separately lubricated. We are concerned only with the pinions and their bearings, and the gears and their bearings, and that is where the system should stop. We all know of the difficulty in the lubrication of roll necks, and I won't say any more about it, except that I think the ultimate solution of that—I may be wrong—is in the roller bearing. When you see these new four-high mills equipped as they are with roller bearings and the activities that the roller bearing people are putting forth, there is no question but that they are well established. We made the mistake of putting oil on some of those roller bearings, the result being that the water washed into the bearing and it washed the oil out. So, although we like to sell oil, we want to sell the right lubricant for the job, and at present, on these roller bearings a uniform grease is the best proposition you have.

J. R. Adams: There is considerable heating, however, on the four-high mill.

L. P. Tyler: On all of those four-high mill roller bearings. I think that is due to the fact that there

is not room enough to put your roller bearings in there.

J. E. Paul*: I would like to answer Mr. Gale's question on how long a lubricant can last. I know of one steel mill that has two large turbo-blowers, each one holding about 500 gallons of oil. It was the practice to dump that every five or six months, when the analysis showed 40% deterioration. They installed a purification system, and after running it a week the oil was in better shape than it was after being in service a day previously, and at the end of eighteen months the oil was exactly in the same condition. They saved about 3,000 gallons of high priced oil.

I might also refer to a central station where they installed a Sharples machine three and-a-half years ago, on a turbine lubricating oil system.

These people use two tanks, one for dirty oil and one for centrifuged oil, each large enough to contain the entire amount of oil in the system.

At stated periods, they dump the oil in the system into the dirty oil tank and refill the turbine system from the centrifuged oil tank. Then, at their leisure, they pass the dirty oil through a heater and a Sharples and put same into storage in centrifuged oil tank ready for the next cycle.

The original oil in both cases is still in operation

H. B. Cleveland†: I have not anything in particular to remark on statements made at this meeting.

However, the way I sum up the situation is that particular attention, today, is paid on lubricating costs based on cents per ton of steel. The total plant lubricating cost being based on cents per ton of rolled steel and finished products shipped. Mills, Open Hearths, Blast Furnaces, Coke Ovens on cents per ton of finished production. Although holding the cost of lubricants as low as possible, we must not skimp too far as to endanger the lubrication of our bearings, by either using an inferior lubricant or not in sufficient quantities. My experience would indicate that there is a happy medium to be reached, between the cost of lubricating and bearing renewals. The labor and material costs of some of the bearings, you have seen shown on the screen tonight will run as high as $900.

What do all these systems mean which have been referred to tonight, if you do not use them correctly? You may be using a system of lubrication which does not apply to your unit to the best of advantage. Each and every condition must stand on its own feet and be given a systematic and thorough study.

Some bearings have a heavy anchorage while others are light. My experience indicates that there is considerable variance along these lines. Just when to use one or the other and whether it is a tin or lead base babbitt.

On steam driven units, particularly steam turbine of the smaller sizes, you must pay strict attention to the packing of your glands. Otherwise the steam leakage will rush through and blow out oil to such an extent, that you will not have sufficient lubricant. There is another thing, which we must watch out for, and that is to get our packing in proper shape on steam engines. If not and your packing is loose, there is a tendency of blowing your lubricant off your engine rods as fast as you can put it on.

Another point which I wish to mention is that Electrical Engineers up to four or five years ago were in a very limited field of lubrication. Most of your fellows have not had to contend with the steam drives that Master Mechanics have had on their hand. Many units are now being electrified which will require your attention to lubricating problems.

My experience indicates that it is very difficult to work out oil lubricating systems on bloomer mill rolls. The present tendency is to put grease shields over the necks to prevent scale and dirt from getting into the bearings, and at the same time preserve the lubricant.

The way I look at the lubrication situation for your Electrical Men is, that it is going to increase as the years go on due to the continued use of Electrical operated mill units, and the steam drive, I believe, is going to gradually disappear. The master mechanic is the man who has the troubles of lubrication on the Steam Engine. As far as your Electrical men are concerned, you do not get into the picture as much as the mechanical men, but as the time goes on you will have more lubricating problems to study and work out. That is all I have to say.

J. R. Adams: The second speaker seems to be throwing up the sponge on sleeve bearings on cold rolling mills. He seems to think the only solution is roller bearings.

L. P. Tyler: Getting into the mechanical features there, I was confining my remarks on the circulating system to pinions, gears and their bearings, and I was steering clear of the roll necks, because in our experience the roll necks have not been adaptable to the use of oil, and considerable difficulty has resulted from the infiltration of water. We have looked with favor on the idea of using a heavy bodied compounded oil on roll neck bearings, applied with mechanical lubricators.

We have on rubber mill calendars applied these oils to the roll necks with excellent results, eliminating thereby the contamination of the rubber by the former lubricant.

George Pfeffer: There is a question I would like to ask in reference to lubricating of roller bearings. Do you advocate the use of oil in preference to grease? or is it a different proposition to ball bearings? In the one case they recommend grease. I would like to know why grease instead of oil.

L. P. Tyler: Our recommendations are, where the bearings are sufficiently tight to retain oil, use oil; where they are not, go to grease. In roller bearings or ball bearings you want something in that will protect your finely polished surface from corrosion.

Charles E. Carpenter: I had the privilege of going through a research on this particular subject—ball bearings. There is practically little friction. What they do want is a cushion, and we do want a rust preventative, something that will prevent corroding, and that is the reason they prefer the more sluggish grease.

We are at the present time controlling the lubrication system on the large ———————— of the Chicago & Northwestern. We have one engineer in charge of that all the time, in conjunction with

*Sharples Specialty Co., Philadelphia, Pa.

†Lubricating Engr., Bethlehem Steel Co., Bethlehem, Pa.

the Timkin Roller Bearing Company. We have not found the lubrication amounts to anything. What is needed is something to protect it from the shock, and grease acts as a cushion or shock absorber.

J. D. Andrews*: Where grease to the large rolls is under pressure, it is possible to automatically open a valve in this greasing line on a definite time schedule and for a definite length of time; the valve being motor operated and the motor in turn functioned by a time cycle contactor, thus doing away with excessive under or over greasing. Over greasing is objectionable for the reason that the excess grease runs down onto the rolls and is ignited by the hot material under process causing a smudge and odor.

Five of these automatic greasing controllers were supplied to a Steel Plant in Ohio. The time cycle contactor is of the repeat type, geared to make revolution in six minutes and to function the motor operated valve control for a period of ten seconds, the grease being under 90 pounds pressure.

Any desired time cycle and time of opening can be supplied and there should be applications of this kind for other greasing operations and possibly the above information will suggest such.

*Automatic Temperature Control Co., Philadelphia, Pa.

*Present Practices in Connection With Motor Driven Rollers**

By J. C. DOBELBOWER†

DISCUSSION

W. S. Hall‡: On the question of speed, where you are rolling a heavy section, it has been our experience that you really do have a braking effect on the first few rollers. You are perfectly justified in cutting out those rollers, opening the switches and letting them run as idlers, because if you have a heavy section like that, your mill will carry the steel out. We have tried that and it has worked very satisfactorily. We have never had any experience in overloading the first few motors for this reason. We find it a hard matter to get the operators to watch the speed. It is just a matter of a little judgment on the first piece that goes through.

F. W. Cramer**: The group drive for runout rollers, mentioned in Mr. Dobelbower's paper, is the type of installation used on many of the older mills. This design has a motor driving a sheave wheel which in turn drives the rollers by means of a cable. There are practically no electrical troubles on this type of drive, the wearing out or breaking of the cable being the main factor in the maintenance costs. On one installation of this sort, driven by a 50 HP. induction motor, the first motor trouble occurred after 15 years of service.

Mr. Hall brought up the question of speed of the individual motor driven rollers. The practice on our mills is to operate the rollers at a speed 10% higher than the speed of the last finishing stand. This is to allow time for the automatic kick-off and hot bed mechanism to function before the next piece is out of the last stand. On the two mills, when the product is ¾ rounds or a lighter product, this increased speed has little effect in the power consumption. On the 10" Mill, where the product is sometimes 3½" squares or rounds, this speed does cause an overload on the first six live rollers. Another cause of overloading on this mill is that the product is not perfectly straight when leaving the last stand of rolls, which results in the weight of the bar being carried on only a few rollers. This same effect results when the rollers are not in per fect alignment. A blown fuse is the ordinary result of these overloads. Trouble of this sort does not cause any mill delay, as one dead roller has no effect on the mill operation.

When this type of run-out roller is installed on a variable speed mill, it is rather difficult to select a speed for the rollers on the mill frequency that will tie in with the rolling schedule. To overcome this, we installed a spare motor generator set that can be used on any of the three mills in case trouble arises in any of the regular sets. In three years of operations, it has not been necessary to use this set which indicates the electrical equipment will stand up under mill conditions.

With about 200 of these individual motor driven rollers in service, for three years, our experience has been that their operation is reliable and maintenance costs very low.

L. A. Umansky*: The subject which has been covered by Mr. Dobelbower's paper certainly deserves comments of this audience after due praise is given to the author for his able presentation.

In the first place, I heartily concur with his idea that ball or roller bearings should be used with the runout table motors. The main argument in favor of ball or roller bearings for this service, as I see it, is not the question of bearing maintenance or oil throwing but the fact that with ball bearings you can afford, everything else being equal, the use of a smaller air gap. Motors of this type very seldom are fully loaded and their power factor is ordinarily quite low, so that the magnetizing or wattless current practically determines the ampere capacity of the machine. Therefore, the smaller is

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*General Electric Company, Schenectady, N. Y.

the air gap, the smaller may be made the motor itself and the smaller may be made the capacity of the motor generator set which furnishes power to these motors. All things considered, it is desirable for the ultimate user not to select arbitrarily too large an air gap. In this connection I would like to hear an expression of opinion of the operating men present at this meeting as to what minimum air gap they have found quite practicable with runout table motors. Some of the mill builders arbitarily specify a .040" gap as the minimum, while some other users feel that a 20 mil gap is plenty large. You ought to know better than anybody else what air gap is satisfactory and it is to your opinion that we should look for guidance.

It is interesting indeed how the idea of individual drive for table rollers gradually grew up. The idea itself is, of course, not new. As early as 1909 the Sharon Steel Hoop Company have installed at their runout tables a number of small induction motors furnished by the company with which the speaker is associated. To Noble Jones, then Electrical Superintendent at Sharon(and now connected with the West Leechburg Steel Company), should be given credit for making the first installation of this kind, which by the way, is in perfect running order up to the present time.

Since 1921 a number of runout table motors were built and installed and have given a very satisfactory account of themselves. Over 2,000 motors of this nature were built by the General Electric Company only.

With such universal adoptation of this new type of drive, the time is now ripe to agree on, and to adopt some common standards. In the first place, we should agree on an universal method of rating these machines. With the speed of these motors being adjusted by varying the applied frequency and voltage, it is quite obvious that the motor horsepower output varies in proportion to the speed; in other words, these drives are of a constant torque type. It is, therefore, misleading and confusing to call, for instance, for a "½ H.P. motor with a speed range from 250 to 500 R.P.M." without specifying whether the ½ H.P. refers to the maximum or to the minimum speed. It is much better and more logical to rate these motors on a continuous torque basis; for instance, in the above example a 5 ft.-lb. motor may be specified which will give approximately ½ H.P. at 500 R.P.M. and approximately ¼ H.P. at 250 R.P.M. The torque rating rather than horsepower identifies the size of these machines. I suggest, therefore, that the Association adopts as a standard the rating of the runout table motors on the coninuous torque basis.

The second suggestion which I have to offer concerns the standardization of the ratio of voltages and frequencies used. If, for instance, we agree that all these motors should be designed to operate at 220 volts when the supply frequency is 25 cycles (and this agreement will be reflected back to the variable frequency motor generator sets) then you might be able to use one spare motor generator set for different tables, or in emergency you could use the 200 volt-25 cycle mill supply, if you have any on hand, and if constant speed of a runout table is better than the complete shutdown. As far as the electrical manufacturers are concerned, it is not difficult for them to build these small motors for any voltage you wish. Each equipment usually involves a quantity of these small motors and, therefore, a special development, if any is involved, is a rather insignificant item as affecting the cost of one motor. In other words, the standardization of the ratio of voltages to frequencies is not so much the manufacturer's problem as the operating men's problem. It is, therefore, for you more than for anybody else to take the necessary action and to agree that, for instance, all equipments of this nature should be designed for 220 volts at 25 cycles, or to select any other standard.

I recommend that the two suggestions which I have just made, namely the universal rating of the motors on torque basis and standardization of voltages and frequencies, be brought to the attention of the Standardization Committee.

W. S. Hall: I think Mr. Umansky has hit the nail on the head on this question of standardization. This is something on which we have hardly scratched the surface as yet as to the number which will eventually be installed, and it appears that this might be a good field for our Standardization Committee to start on before it is too late. The longer we wait, the more complicated it becomes.

On this question of ratings, there is no question but that there should be something drawn up by the Standardization Committee which would at least assure each manufacturer that they are all bidding on the same basis as to capacity.

F. E. Harrell*: I would like to comment on a few of the points that have been raised. Concerning gaps, there is not the same problem in the Schloemann motor roller, which is the type of roller that Mr. Dobelbower referred to as having been previously mentioned before the Association by Mr. MacCutcheon. The gap, of course, can be safely made smaller, relatively speaking, than in the individual motor drive. That is, in this case, the whole roller is combined in one element with only two bearings and it lends itself much more readily to a smaller gap for that reason. In other words, any movement of the roller moves the whole electrical element as well, so in the motor rollers we work with about a 20-mil gap. In fact, it can be reduced even to 15.

It may also be of interest to note in connection with all of the Schloemann motor rollers that have been applied in this country thus far, that they have all been rated on the torque basis. That may be of interest to your Standards Committee, something to spur them on in any event. The horsepowers, of course, are all less than one, and to some operating men who have had no experience with individual motor drives, it may seem ridiculous to think of applying less than a one-horsepower motor to a table that has maybe sixty motors in it and has previously been run with a 100 or 150 horsepower motor. However, it is purely a matter of torque, so all of the Schloemann motor rollers have been rated on the torque basis.

Incidentally, this is something that has fooled all of us. All of these rollers that have been supplied thus far have been designed with at least twice as much torque as any of the applications on which they have been installed have required, so it

*Reliance Electric & Engineering Company.

may be that we may be mistaken somewhat if we try to translate the horsepowers which we think the rollers will take into terms of torque, because we find that the actual torque required is very small. These rollers, of course, are primarily high torque motors, that is, they are designed to develop the maximum torque at starting, making sure that the pull-out point is not too near.

To touch upon the other point that Mr. Dobelbower mentioned, that of heating, as he brings out, in the case of the Schloemann motor roller the hot stock is traveling over the surface of the motor which is ordinarily used in a general purpose motor for dissipating the heat within the motor itself. We have found, however, that the mass which is combined in the whole motor roller is sufficient to dissipate that heat without reaching a dangerous temperature within the roller.

It may also be of interest to the Association to know that the motor rollers of the Schloemann type have been applied to certain applications of which I find some are surprised to know. One of these is in a tube mill for conveying solid rounds up to 12 inches in diameter by 10 to 12 feet long, so you can see that the motor rollers which have been thought by some, I think, to be more or less limited in the scope of their application, can be extended to practically any application in which an individual motor driven mechanical roller might be applied, as well as to certain others where the individual motor driven roller is not at all suited.

J. F. Headlee*: After Mr. Dobelbower's paper on "Present Practices in Connection with Motor Driven Rollers" a brief description of an installation of Rollout Motors may be of interest.

The installation was made in a D.C. Motor driven 10" Strip Mill in 1927 and has been in continuous service since.

The type is one to which Mr. Dobelbower referred, namely the squirrel cage induction motor, with rollers on the extended rotor shaft. The motor is a variable frequency type. 9½/25 cycles being the range in frequency, which on a four-pole motor gives a speed range of 265/725 R.P.M. Bearings are anti-friction. Ventilation is provided by built-in fans inside of roller.

The motor rollers are located at the top of an inverted "V" double hot-bed, which allows one motor to drive two rollers, one on each end of the shaft.

There are 150 motor-rollers in the roller line.

The speed of the roller line may be varied from 700 R.P.M. to 1900 R.P.M. which is sufficient to take care of the variation in mill delivery speed.

The motors are supplied with power by a Motor-Generator set, the motor being a 600-volt D.C. variable speed 125 H.P. motor and the generator a three-phase variable frequency 43-115 K.VA. synchronous generator.

Overload, overspeed, undervoltage and necessary interlocks are provided.

The operation of the roller motors is controlled from the mill pulpit by the operator who also controls the Train Motors. This is done by bringing the variable frequency M-G set up to speed simultaneously with the Train Motors; this being accomplished by armature voltage control. At a given armature voltage a relay closes the exciting circuit to the variable frequency generator, which causes the roller motor to come up to speed simultaneously with the Train Motors.

Remote control of motor field and tachometer are provided in the mill pulpit.

The excitation of the variable frequency generator remains fixed at a predetermined value.

No difficulty has been experienced in the operation and maintenance of the roller motors, except at the first when the roller motors were energized at too high a frequency, this resulting in blown fuses. This difficulty was overcome by energizing the roller motors at a lower frequency.

Maintenance of the motor roller has been a small item, not a single motor change being made to date, and they certainly have many other advantages over other types of table drives.

A. F. Kenyon*: In the past, individual motors for the drive of table rolls have been applied only on tables which run continuously in one direction or which are stopped or reversed at infrequent intervals. In the few cases where the applications required frequent starting and stopping, control has been effected by plugging the motors.

Plugging control can be made very simple, but this scheme has two principal disadvantages in that a large capacity supply source (variable frequency generator) must be available to carry the plugging peak load, and in that the heating of the induction motors and of the supply generator is very high if reversals are frequent. One solution of this problem was incorporated in the proposal to provide a supply generator set which could be started, stopped, and reversed rapidly, the roller motors being permanently connected to the generator and their speeds following that of the generator in direction and value. This method of control very greatly reduced the heating of the A.C. machines but resulted in other complications.

An application is now being made of about 135 motors on five tables of a bar mill. The arrangement of the mill requires the quick stopping and starting of each table between the rolling of each successive bar. For this difficult application, a new scheme of control has been developed, and by its use better operating results are expected.

The motors on each table are supplied from a separate variable frequency motor generator set. With the controlling master switch in the off position, the set runs at its base speed and the motors are disconnected from the generator. Movement of the master switch to the running position connects the motors to the generator, and over-excites the generator to improve the starting torque. The motors thus accelerate rapidly to the minimum speed at which point relays operate to accelerate the set to the desired speed as determined by the field rheostat setting and to reinsert the normal generator field resistance. During stopping, both the generator and motor field rheostats are shunted, so that the motors are rapidly retarded to the minimum speed at which point they are plugged and retarded to rest.

*Test Engr., Gary Works, Illinois Steel Co., Gary, Ind.

*Engr. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

With this control method the motors are always started or plugged at low voltage and frequency, so that the motor heating is reduced to from one-half to one-third of that when plugging from the maximum frequency.

F. B. Crosby*: I had no intention of discussing this subject although it is one in which we are much interested. The use of the individual motor driven roller dates back some twenty years or more though in a very limited degree until about ten years ago the Morgan Construction Company adopted the individual motor drive for the hot runout rollers on certain of its cooling beds. Since then we have used more than 900 of these units with most satisfactory results. In fact the success attained with these Morgan drives has led o the rapidly increasing general use of the individual motor driven roller, even for applications where it is possible that the greater complexity and lower efficiency is not justified.

Our requirements were unusual in that our cooling beds and accompanying hot runouts are often 600 feet or more in length and demand a large number of relatively small adjustable speed rollers. In some of our patented beds these rollers are cone shaped with an element of the cone lying in a horizontal plane and so mounted that the entire unit may be oscillated about a vertical axis in such a manner as to secure simultaneously a lateral translation and retardation of the stock as it comes on to the bed.

These rollers were formerly driven by a cable which unfortunately had a habit of breaking Monday morning instead of Saturday night. The resulting loss of production added to the cost of replacement cable and labor every month or six weeks was prohibitive so that the greater reliability of the individual motor drive more than justified its slightly greater first cost.

We have had no direct experience with the so-called "motor roller" but assume from what we have heard that experience is rapidly accumulating. There are no doubt numerous places where its application will be warranted, although in many cases where the individual drive is desirable it would seem that a standard motor connected with a flexible coupling to a standard roller—a construction we have often used—would be lower in first cost and equally effective.

Fortunately since frequency and voltage both vary in proportion to the speed required, the flux remains practically constant throughout a wide range of speed adjustment and the motors operate very nicely on a constant torque basis from 60 cycles down to 10 cycles, which is as low as we have yet found it necessary to go. Ball or roller bearings and a 20 mil air gap have proven quite satisfactory.

As regards the successful application of "motor rollers" to frequent reversing duty, much has yet to be proven. We confess to a prejudice in favor of the direct current series or compound mill type motor and geared drive, but we are willing to learn.

R. M. Hussey†: Mr. Chairman, may I mention, please, a point in connection with motor rollers on reversing service. We are about to apply some of these motors to reversing service and it is pretty stiff reversing service at that. And it may be that at next years meeting we may have more explicit information on that kind of service.

A. L. Foell†: We have three double cooling beds at the Donner Steel Company in which all center-runout rolls are driven by cables. The 14 inch mill cooling bed, which is 135 feet long, is provided with two cables for driving these rollers. These cables drive the rolls by means of sheaves located at the two extremities of each roller. The 10 inch and 8 inch mill cooling beds, which are 421 feet and 365 feet long respectively, each have one cable driving double run-out rollers. The life of these driving cables varies between two and thirteen weeks. The best life so far obtained has been slightly over three months.

All of the 200 odd rollers on these three cooling beds are provided with roller bearings from which we have experienced practically no difficulty. The entire expense in the maintenance of these runout tables has largely been occasioned by the necessity for frequent replacing of cables.

In regard to the proper speed for operating center-runout rolls to which Mr. Hall has made reference, we have not found it necessary to provide means for definitely synchronizing the run-out rollers with the finishing pass of the mill. In the 14 inch mill, which has a constant speed finishing stand, the speed of the run-out rollers is only very slightly above that of the finishing stand. In both the 10 inch and 8 inch mills, where the finishing stands operate at a variable speed, the speed of the run-out rollers on the cooling beds is generally set considerable above that corresponding to the delivery of the finishing stand to the extent of, I dare say, at least 10 per cent. This has a tendency, particularly on small bars, to straighten them preparatory to being delivered to the cooling beds.

We have on numerous occasions considered the application of motor rollers of both types now on the market to our 14 inch mill bed but have been handicapped by the fact that this bed, like the rest of our beds, is a close coupled double cooling bed and further by the fact that on certain occasions these rollers must positively be stopped after each bar has been delivered to the bed and again started when the succeeding bar comes on. The operation of stopping these rollers is simplified by stopping one motor as is now the case in this particular drive and seems to me is a matter not as readily accomplished by a group of separate motor rollers even if all rollers are operated by one controller.

W. S. Hall: I think while we have been able to bring out a good deal of discussion today, that a year or so from now we will be able to get some very definite data, particularly as to reversing service.

*Elec. Engr., Morgan Construction Co., Worcester, Mass.
†Elec. Supt., Jones & Laughlin Steel Co., Woodlawn, Pa.
†Chief Engr., Donner Steel Company, Buffalo, N. Y.

*Factors Which Influence the Choice of Waste Heat Boilers**

By J. B. CRANE†

INDUSTRIAL plants of today require furnaces for heat treatment of material. The gases leaving these furnaces are discharged to the atmosphere at temperatures above 1000 deg. Fahr. and the heat between the discharge temperature and the temperature of the surrounding air is wasted. Boilers installed for the recovery of this heat are commonly referred to as waste heat boilers.

A few years ago, the popular and technical papers were full of articles telling of enormous amounts of money being lost due to the water powers of the country not being fully developed. You, here in Birmingham, know of the outcry about Muscle Shoals. In a majority of cases, the undeveloped water powers are many miles from a market and require long and expensive transmission lines to bring the power to the point of use and in many cases standby steam plants are necessary to guard against transmission line interruptions and periods of low water.

Waste heat, on the other hand, is at the market, and the heat, if not utilized, is, like water over the falls, gone forever. When the furnace is not operating, there is usually no demand for the steam, consequently, the waste heat unit, requires no long transmission lines nor standby plants. One company, with which the writer is familiar, has, in the past six years, furnished over 250,000 sq. ft. of boilers for waste heat service and on a conservative basis, the owners of this equipment are saving 200,000 tons of coal annually.

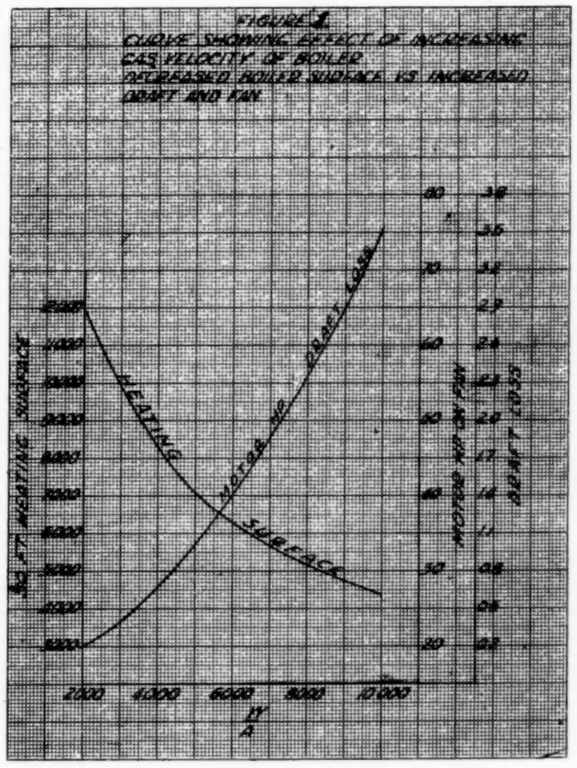

FIG. 1.

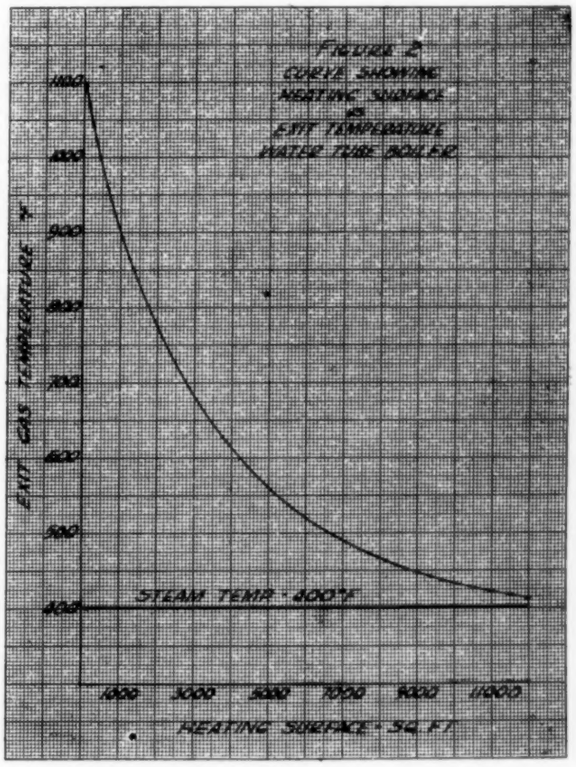

FIG. 2.

Some installations have been made and on account of a lack of understanding of the problems involved have not proven satisfactory. These are in a minority and there would be a much greater number of installations today, if the factors effecting the choice of this equipment, were better understood.

Most of the early units did not produce the results expected, on account of lack of draft. Efforts were made to install the boilers between the furnace and the stack and still maintain the draft at the exit of the furnace. This meant a boiler with little or no draft loss and a boiler with this draft characteristic will absorb very little heat.

*Presented before Birmingham District Section, A. I. & S. E. E., April 28, 1928.

†International Combustion Engineering Corporation, New York, N. Y.

This is shown more clearly in Figure 1.

The assumptions are—Boiler, two drum, vertical, three passes.

Lbs. of gas per hour	90,000
Temperature entering boiler deg. Fahr.	1,100
Feed water deg. Fahr.	212
Exit Temperature from boiler deg. Fahr.	500
Pressure—Lbs. per sq. in.	250

You will note that with 12,000 square feet of heating surface, these results will be secured with two-tenths of an inch draft loss and a 20 H.P. motor driving the fan or by means of a stack and natural draft. The cost of such a unit would probably not be warranted on account of first cost. The extreme for this type of boiler today would probably be 4,400 sq. ft. of heating surface, three and five-tenths draft loss and a seventy-five horsepower motor on the fan. This would also probably be prohibitive on account of the power required for driving the fan. The most economical means would lie in between but this does not tell the complete story. It is not possible to get the exit temperature below the temperature of the water in the boiler and, as we more nearly approach this point, a larger and larger amount of heating surface is required. See Figure 2. The same assumptions are made as in the previous case except the exit temperature varies.

It will be noted that to reduce the temperature to 600 deg. 4200 sq. ft. of boiler surface is required; the next 100 deg. reduction in temperature requires 6700 sq. ft. or over 50% additional surface; the next 50 deg. reduction requires 8800 sq. ft. or 35% additional heating surface for the last 50 deg. or over 100% additional heating surface for the last 150 deg. Many propositions have been turned down because they have been estimated on recovering the last B.T.U. in the gas rather than on an economical balance of all the factors involved.

Let us make some more assumptions.

There is a market for the steam and additional investment is required for the boiler plant only. This condition prevails at most steel plants. The boiler installation can be installed for $5.00 per square foot, steam is worth $.40 per 1000 lbs. Operating costs are $6,000 per year, no matter how many horsepower is installed. See Figure 3.

FIGURE 3

Exit Temp.	Sq. Ft. of heating surface	Estimated Cost	Lbs. of Steam per hour	Annual Value 6000 hours 40c per M lbs.	Net Value Cost of operation $6,000	% Return on investment
600	4,200	$21,000	10,260	$24,600	$18,600	88.5
500	6,700	33,500	12,320	29,600	23,600	70.5
450	8,800	44,000	13,335	32,000	26,000	59.0
425	10,600	53,000	13,851	33,200	27,200	51.5

A 50% return on the investment as shown in Figure 3 with 10,600 square feet of heating surface looks attractive, but, lets analyse it still further. Uusually there are ten or more furnaces to be equipped. It is much easier to get an appropriation for $210,000 showing 88% return than $530,000 showing 50% and there are probably other places where money will earn more than 50%. Most companies today look upon an increment investment. Let us reconstruct the table shown in Figure 3. See Figure 4.

FIGURE 4

Exit Temp.	Estimated Investment	Increment Investment to secure lower temp.	Annual Valuue	Increment Value above Lower temp.	% Return
600	$21,000	$21,000	$18,600	18,600	88.5
500	33,500	12,500	23,600	5,000	40
450	44,000	10,500	26,000	2,400	23
425	53,000	9,000	27,200	1,200	13

As an actual matter of fact the operating expense for the greater output will be a little greater on account of more power required for the fan, but this increases very slightly as the fan is a volume machine and as the temperature decreases the power required for the fan decreases and if at some future time it is desired to install economizers the reduction in temperature of the gases through the economizer will be found to just about balance the increased draft drop and the same fan and motor will handle the unit.

When the matter is looked at in this light, it immediately becomes apparent that it is much better to pick a smaller unit and indicates one of the reasons why many waste heat installations have been side tracked.

All of the discussion thus far has been on water tube boilers, to illustrate the principle involved. There are many installations of return tubular boilers for this purpose. The factors effecting their choice are very clearly set forth in an article before your Association by a former chairman of your Combustion Division.*

Certain requirements of waste heat work are most admirably met by this type of boiler.

1—Setting must be tight to prevent infiltration of air. This is more important in waste heat work than in any other class of work. The draft inside of the setting is high due to high velocity of the gases and the necessity of having a suction at the front of the boiler in order to give proper furnace operation. This type of boiler is ideal for this purpose.

2—Setting must be well insulated to prevent loss of heat by radiation. This accomplished, in this type of boiler by lagging the outside of the boiler shell.

3—Velocity of gases should be high. This is easily accomplished in this type of boiler and by using small tubes spaced closely together the maximum heat transfer can be obtained.

4—Draft loss should be low. This is most readily accomplished with this type of boiler as the gases make a straight shot through the tubes with not more than one turn, and the turn, if required, can be designed to give the least possible obstruction to the flow of the gases.

The above factors combined with low first cost of boiler and installation in a small space makes this boiler very attractive for waste heat work. What are its limitations?

*G. R. McDermott, Proceedings A. I. & S. E. E. 1921, Page 351.

Superheaters

If superheaters are required, they must be installed in the flue leading to the boiler or directly in front of the boiler. Assume the boiler is operating at a constant rating and the furnace suddenly emits a larger amount of gas than usual or the temperature of the gas is suddenly raised. These gases strike the superheater first making an abrupt rise in superheat which prevails until the gases strike the boiler and the boiler generates more steam. On the other hand suppose the quantity or temperature of the gas is lowered, the opposite effect takes place and the superheat drops. There may be a change of over 100% in the superheat temperature between minimum and maximum conditions. With a water tube boiler, the superheater can be installed back of some boiler heating surface so that the gases strike some boiler heating surface first and the fluctuations are not nearly as severe.

Pressure

On account of structural difficulties, the return tubular boiler is limited to 250 pounds. The water tube boiler is now being built up to 1400 pounds pressure and it will not be many years before the steel plants will be considering higher pressures than the 200 lbs. to 250 lbs. they are now using.

Quantity of Gases

On account of structural difficulties, this type of boiler is limited in size and unless two or more boilers are used in multiple 100,000 pounds of gas is nearly the limit that this type of boiler will handle.

Dust Troubles

The return tubular boiler has not been tried in cement plants for fear of cutting tubes at the high velocities used. There may be other gases that are dirty enough to cause trouble of this kind. There have also been some difficulties due to dirt collecting at the entrance to the tubes. It is very easy to change velocities in a water tube boiler if there are one or more baffles but this cannot be done with the return tubular boiler. The early installations of this type of boiler were installed in a vertical position. Some trouble developed, when the gas entered at the bottom due to dirt and scale collecting on the inside of the bottom plate, the plate becoming overheated, and loosening tubes. When the gases enter at the top, steam collects on the inside of the plate, the plate becomes overheated and loosens up the tubes. Tubes have been welded after being rolled, the boilers have been inclined from the vertical, so the steam bubbles will release themselves from the inside surface and an auxiliary steam drum above the level of the top plate so that there is a head to keep water in contact with the plate; the top plate has been dished in another design and the steam space has been placed above the top plate. If the boilers are installed in a horizontal position, all trouble of this sort is obviated.

Auxiliary Firing

Waste heat boilers usually operate around rating or about 3½ lbs. of steam per square foot of heating surface. If many boilers are installed, there is a large amount of heating surface that can be put to use to help take care of peaks or emergency conditions. These boilers will readily respond to auxiliary firing by oil or pulverized coal. The suction at the entrance to the boiler, usually does not exceed 0.5 of an inch of water and as most oil and pulverized coal burners require a pressure of two or three inches of water, it means the pressure required for their operation will be reduced by this amount. The weight of waste gases going through the boiler usually corresponds to 200% or 300% rating on the boiler so that the induced draft fan must be large enough and have sufficient power to take care of the increased draft loss.

Temperature

The return tubular boiler absorbs very little temperature by radiation and the water tube boiler absorbs the maximum amount of heat by radiation. The absorption of heat by radiation varies as the fourth power of the temperature. Lent and Thomas made some experiments at the Rhine Steel Works.*

Log. Mean Temp. over Steam Temp. of 413 deg.	B.T.U. per sq. ft. per hour absorbed by boiler only	
	Measured Values	Computed Values
600	1000	400
1200	3600	2300
1800	9000	6700
2400	17100	14000

Blast furnace gas 48.42" thick—21% CO_2—24% water vapor.

From this it will be noted that if the temperature of the gases from the furnace is 1400 deg. or over, the water tube boiler may offer greater possibilities.

Vertical Vs. Horizontal Water Tube Boilers

As between these two types of boilers, opinion is divided as to their relative availability in about the same way as for other work. There are good installations of each type, also poor installations of each type. If horizontal boilers are used, box header boilers are probably less likely to leak than sinuous headers because the draft loss is higher than with ordinary boilers and, consequently, the suction is greater and there is less chance for leaks with the box header. In steel mill work, the vertical boiler is usually preferred, and many engineers feel it is more easily kept clean than the horizontal boiler. With a vertical boiler or a vertical boiler and vertical economizer, the fans can be kept on the floor so that one man can easily look after everything. By using two or four passes, the same thing can be done with the horizontal boiler. The writer knows of one case where a horizontal boiler was installed with four passes and an economizer at the rear of the boiler. The baffling was changed to give two passes through the boiler. The exit temperature at the exit of the economizer went up only ten degrees. The power required by the fan was decreased to a point where the net amount of steam from the boiler was greater than with four passes. Such performance depends upon the relative heating surface of boiler and economizer and would not follow in all cases.

Settings

As stated before, the return tubular boiler requires lagging only but with the water tube boilers, more care must be taken, than with ordinary boiler

*"New Data on Heat Radiation" in Mechanical Engineering for January, 1925.

settings to keep the setting tight and to prevent possible damage due to explosion. There should be some explosion doors and buckstays very carefully designed to see that all stresses are properly provided for. In many cases, waste heat boilers have been steel encased and this is particularly necessary with horizontal boilers. With vertical boilers, many installations have had the brick casing coated with a bitumastic coating which has effectively sealed the setting against leaks, presents a neat appearance and needs very little attention to keep tight. The setting should be insulated by some form of insulating brick. If a row of common brick is put outside the insulating brick, it supplies sufficient protection for same. The inside of the setting usually consists of two rows of second quality of firebrick tied at intervals to the outside rows of common brick. In many cases, second quality firebrick is used in place of the outside row of common brick. It does not greatly increase the cost and presents a neat appearance. If the steel casing is used, the outside row of bricks is usually omitted and the casing put directly back of the insulation.

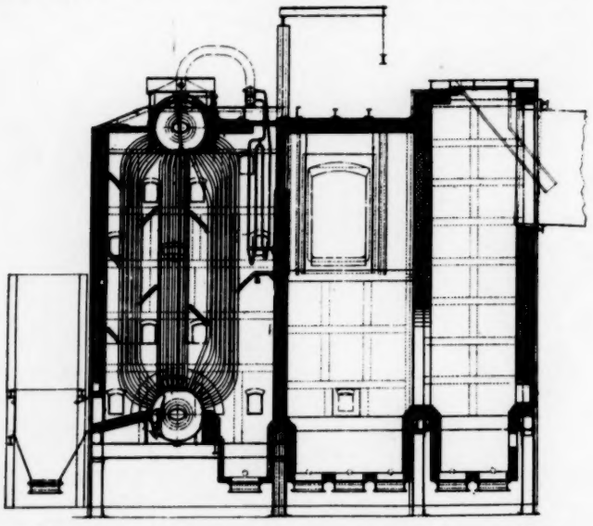

FIG. 5—Vertical Waste Heat Boiler Cement Plant

Fans

In cement work, high speed fans have been installed and had to be replaced in six months, in other cases double inlet slow speed fans with the inside of the casing protected by cast iron or other abrasive resisting material have lasted for several years. The fan is one of the crucial points of design for a waste heat installation. It must be large enough not only to handle the gases from the furnace but also air drawn in through leaks. It is usually found a waste heat boiler increases the output of a furnace due to better control of draft conditions, so it should be large enough to take care of some increase in output. The drive of the fan should be large enough not only to provide draft when surfaces are clean, but also when they are dirty and to allow for emergency conditions. There may be a hole, or something else develop and it is desired to maintain production for a limited period and a proper choice of fan will allow for this contingency. The fan drive should have a variable speed of at least two to one.

Dampers

You are already familiar with various types of dampers in connection with your furnace work. The same principle, applies to waste heat work and the same damper will be found to work equally well for high temperatures. For the rear end of the boiler, if more than one unit is connected to a common duct louvre dampers work well. Plate dampers are so large that a little difference of pressure on each side, makes them difficult to manipulate.

Performance Data

A water tube boiler, that has proven very satisfactory, is shown in cross section in Figure 5. This is one of two 800 H.P. boilers installed at a cement plant. Similar boilers are installed on open hearth plants and billet heating furnaces.

Performance of these boilers is shown in Fig. 6.

FIGURE 6

Boiler—Two Drum, three pass Heating surface Sq. Ft.	Type of Furnace	
	Iron Melting	(1) Cement Kiln
Boiler	3,000	12,000
Economizer	None	4,100
Superheater	None	390
Total Heating Surface	3,000	16,470
Production of Furnace	30 tons—8 hrs.	1200 bbls.—24 hrs.
Pounds of Gas per hour	37,500	128,800
Pounds of Steam per hour	14,000	25,000
Entering Temp. Boiler deg. Fahr.	2,120	1,209
Exit Temp. Boiler deg. Fahr.	550	468
Exit Temperature Economizer		330
Draft Loss inches—boiler—superheater and economizer	0.8	1.31
Pressure pounds per sq. in.	125	150
Feed Water deg. Fahr.	210	195
Superheat deg. Fahr.	0	106
% Rating total surface	121	51

(1) This boiler normally takes gases from two kilns—During test only one kiln was in operation.

Messrs. F. H. Wilcox and J. C. Hayes* give some interesting information on return tubular boilers. See Figure 7.

In Figure 8 are given some figures on horizontal boilers on cement kilns. I have been unable to get any figures on this type of boiler on steel furnaces.

At the present time horizontal boilers with tubes twelve feet long with twenty or more rows high and gases passing directly through the boiler in a single pass are being used on water gas sets. These are giving much better results than the usual horizontal boiler adapted to waste heat work and have promising possibilities.

FIGURE 7

Boiler—return tubular—2" tubes—18 ft. long—superheater ? ft. 25 ton open hearth furnace. Boiler heating surface 2500 sq. ft.			
Pounds of gas per hour	38,500	39 800	43,200
Pounds of steam per hour	7,641	7,899	8,582
Average oil consumed—gallon per hour	152.7	155 2	160.5
Temperature entering boiler—degrees Fahr.	1,348	1,338	1,331
Temperature leaving boiler—degrees Fahr.	485	490	478
Draft loss—superheater and boiler	2.57	2.55	2.50
Pressure—pounds	140.9	140.0	133.8
Superheat—degrees Fahr.	134	112	126
Per cent rating—boiler	102.5	105.0	114.5

FIGURE 8

Boiler	(1) Heine	(2) B. & W.
Passes	4	3
Heating Surface—boiler—square feet	7,050	15,300
Heating Surface—Economizer—squire feet	2,448	None
Heating Surface—Superheater—square feet		691
Total	9,498	15,991
Type of furnace	Cement	Cement
Number of furnace	1	2
Production each furnace	1000 bbls. per day	1250 bbls. per day
Pounds of gas per hour		166,000
Pounds of steam per hour	19,800	32,000
Entering Temperature—Boiler degrees Fahr.	1160	1275
Exit Temperature—Boiler degrees Fahr.	460	426
Exit Temperature—Economizer degrees Fahr.	340	None
Superheat degrees Fahr.	100	135
Draft Loss Br. Sup, two econ. inches	6.4	6 35
Per cent Total Ht. Surface Pressure, Lbs. per sq. in.	175	154
Per cent Rating	70	67

(1) Cape Giradeau Plant, Marquette Portland Cement Company.
(2) Louisville Plant, Louisville Portland Cement Company.

Figure 9 is a photograph showing a waste heat boiler steel encased. This is a two drum vertical boiler on a cement kiln.

Figure 10 shows a horizontal boiler for waste heat work being erected.

*Waste heat boilers in steel mills Western Society of Engineers, November 16, 1925.

Conclusion

Economical possibilities require a study of all problems where there is heat in gases above 1000 deg. Fahr, being discharged to the atmosphere.

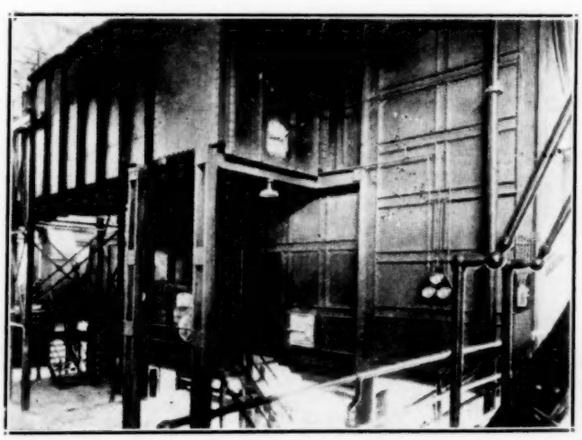

FIG. 9—Waste Heat Boiler Steel Encased

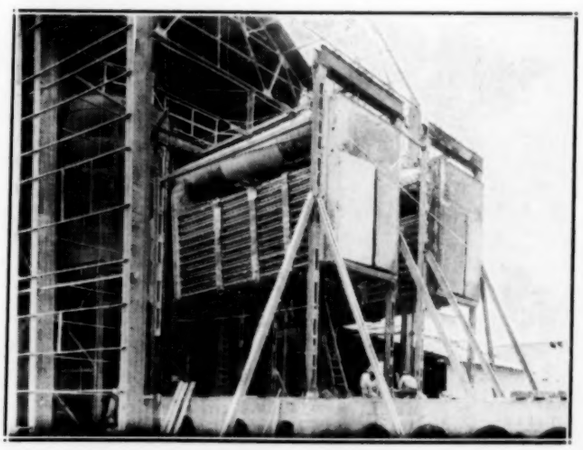

FIG. 10—Horizontal Waste Heat Boiler for Cement Plant

(1) If the pressures, weight and character of gases is suitable, the return tubular boiler will give the maximum results at the least outlay.

(2) If the conditions are not suitable for return tubular boilers, the vertical boiler is the most suitable boiler.

(3) The single pass horizontal boiler is suitable for special conditions and maybe used in some cases in place of vertical boilers.

DISCUSSION

Martin J. Conway*: Mr. Crane's paper is a valuable contribution to the Association's files. The question of waste heat boilers is a very important one in the engineers program of fuel conservation and there are many installations in use today which will perform better if the necessary minor changes are made to them.

Probably 50 per cent of the horizontal water tube boilers operating as waste heat units can have their performance increased by improved baffles, allowing a greater transfer of heat in the first pass of the boiler.

We spend several thousand dollars putting in waste heat boilers and in the majority of cases these boilers are installed with little more in the way of instruments than the state laws call for—a steam pressure gauge and probably a draft gauge to tell us when the boiler is very dirty.

At our Association Convention in 1926, in discussing Mr. Leahy's paper on Gas Producer Operation† I pointed out that gas producer manufacturers should include the necessary instruments as part of their quotation and I understand that recently this suggestion has been acted on. I believe the same suggestion will readily apply to the makers of waste heat boilers. In addition to the steam pressure gauge and draft gauge, there should be included at least a recording steam flow meter and temperature recording devices for inlet and exit gases as part of the boiler equipment in the manufacturers quotation, leaving the particular type of instruments to the discretion of the purchaser in order that he may standardize his instrument equipment if he desires.

A raise of 50 to 100 degrees in the exit boiler gases may not make any difference to the draft gauge reading but it certainly represents a loss in operating efficiency which will probably point to the fact that the tubes need cleaning long before a loss of draft is noticed.

The layout of a waste heat boiler installation in connection with any type of furnace needs careful engineering. The waste gas by-pass flue to the stack should be made plenty large enough to take care of the furnace gases if for any reason it is found necessary to isolate the boiler and the stack should be large enough to exhaust the gases from the furnaces.

The flue valves should be so designed as to offer very little resistance to the furnace gases. Very often the boiler fan is called upon to overcome defective flue design external of the boiler.

With proper flue, valve and stack design it becomes an easy matter to isolate the boiler, put the furnace on the stack and thoroughly clean the boiler in a few hours when necessary.

*Chairman, Combustion Engineering Division, A. I. & S. E. E., Fuel Engr., Lukens Steel Co., Coatesville, Pa.

†Proceedings for 1926, Page 188.

*Recording and Controlling Instruments in the Iron and Steel Industry**

By C. C. EAGLES AND ROY M. WALKER†

DISCUSSION

C. L. Saunders‡: Before entering into any discussion of Mr. Walker's paper, I want to take the opportunity to compliment the completeness with which he has gone into a very comprehensive subject: Instruments in the Iron and Steel Industry. Not only has he described many installations, both in his recitation of the paper and in the printed matter, but he has given us a complete outline and resume of all instruments, used from the mine or quarry down to the finished product. He not only has given us the applications but the advantages and specifications as well. This is a very interesting report.

Purchasing and installing instruments is one operation, but maintenance is another. Maintenance might be described as your insurance against disuse of loss of expected advantages from the installation. The amount and quality of the maintenance is a direct function of the type of instrument and the character of the installation. Mr. Walker suggested that one man be appointed to ink the pens, change the charts and take care of work of this kind. I want to enlarge on this point and emphasize its importance.

Some of you men are representing plants that are large units, that have a complete outline of instruments in considerable detail. In those plants you can organize an instrument department which will be a profitable investment. Some plants are perhaps organized already along these lines, but if you will select some bona-fide person, someone who has patience, mechanical skill, and who likes to adjust and make corrections to small parts such as are

*Presented at A. I. & S. E. E. Annual Convention, June 27, 1928.

†Engineers, The Bristol Co., Waterbury, Conn.

‡Brown Instrument Co., Philadelphia, Pa.

found in a number of instruments, you can hold him responsible for the instrument operation in your plant. It is the best insurance that you can place in an instrument installation. He should have proper space, of course, to work in, and give him tools to use.. They can be utilized in not only outside checking of an instrument installation, but in proper repairing of an instrument that needs a laboratory job. We very frequently find elaborate electrical repair shops, with facilities for repairing motors, winding armatures and other work of that class, but it is seldom that we find an efficiently organized department in this so-called specialized work.

In the smaller plants that may not have sufficient instruments, or in the large plants that do not have a sufficient quantity to organize a department, you will find it well, I think, if you will appoint some one man, say, from the electrical force or other suitable department to be held responsible for each instrument installed both as to the instrument's mechanical performance and the purpose for which it was purchased. In this way you are assured of getting the best results from the installation that has been put in, and it is then you will realize the benefits that Mr. Walker has brought out in his paper.

W. J. Harper*: Mr. Chairman, in regard to instruments that are used to measure power, there is one point that I would like to bring out, is the measure of manpower by the installation of recording wattmeters in our shops. We now are going to put recording meters in our electrical shop and machine shop. The meters, as we see it, are to save power and reduce the cost. We know in our shops that we are paying for ten hours; we know they are not going to work at 7:00, we know they stop before 12:00, and they are not starting at 12:30 and they are quitting before 5:30. The measure of manpower, I think, is just as important as the measure of purchased or electrical power.

Another advantage of the recording meter is the saving of fuel. Today the blast furnice gas is one of the most efficient fuels we have in the steel industry. If we put recording meters on our blast furnace stoves and take stoves off on stack temperatures instead of the old rule of two hours on gas and an hour on air, we will have at least five per cent more fuel to put under the boilers for the generation of power or for the operation of gas blowing engines.

We have recently purchased an oil-electric locomotive, and instead of putting three men on to make a time study, we bought a recording meter. We felt that in 24 hours we were losing an hour, due to lost time in the movement of the locomotive. Instead of that, to our surprise we found out that in every 24 hours we were losing six hours, and from these results, instead of operating four locomotives per shift, we feel sure that we will be able to operate our plant on three.

In regard to the maintenance of meters, as Mr. Standing said, we get a lot of charts in and if no one looks them over and makes a study of the chart, it means nothing. It is one thing to put a chart on and it is another thing to interpret what the chart means.

*Comb. Engr., Donner Steel Co., Buffalo, N. Y.

I wish to state that I certainly enjoyed Mr. Walker's paper and his various applications of graphic and recording meters in the steel industry.

A. J. Standing*: Mr. Chairman, the question of instruments comes up repeatedly in most plants. As electrical men, we handle a product, and that requires an accepted number of meters and instruments. The combustion field is practically in the same position that we are, they have constant use for a number of accepted instruments. But, aside from these two distinct lines, it is sometimes very hard to get the instrument idea across to the Operating Department. There is still a good deal of suspicion connected with instruments which are being installed, not only among the men themselves but oftentimes among the heads of the departments. They seem to feel that, you put them in as a check-up on their personal efficiency, and therefore it is a part of the engineer's job in the plant to sell the idea of instruments, both to the men in the plant and to the management. The management often times looks upon the purchase of instruments as just another additional "trimming" that could very well be done away with.

If instruments are going to pay for themselves, the story which the instruments tell must mean something. When that story does mean something, some action must be taken to change, correct or maintain conditions as the instruments indicate they should be maintained. There is no use installing a battery of expensive instruments and letting them record data and pay no attendtion to them and do nothing with the results which they record. We have seen that happen with different instruments—it is like the man tapping a car wheel, and wondering what he does it for,—we simply change charts and the charts are put away on file and never studied or analyzed with a view to arriving at conditions which are better than the conditions which the charts indicate. I think the tendency, however, is coming very rapidly, particularly with the adaptation of electric heat to industry, to use more instruments, not only to control the power and power cost, but to control heat operations in such a way that we may get the best results from accurate heating.

J. H. McElhinney†: I would like to elaborate just a little on what Mr. Standing said. Steel isn't just plain steel any more. Everybody who wants something wants it made the way they want it. There are more special steels and more specifications, I think, being exacted of us than there ever were before, and it is therefore developing more and more very specific requirements on heat treatments and there is a chance, I think, still, for a good bit of development along that line. Possibly the instrument people have everything we need and we are not using it, but it is undoubtedly true that we have to work more accurately on heat treatments than the steel industry as a whole has worked in the past. We are feeling it and everybody else is feeling it.

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The Insulation of Open Hearth Furnace Regenerators*

By L. B. McMILLAN†

DISCUSSION

W. Kennedy‡: It is generally acknowledged by steel plant and fuel engineers that parts of these furnaces can be insulated to very good advantage, the limiting factor being the ability of refractories to give a satisfactory life under the conditions to which they are subjected.

It is now general practice to insulate around the checker chambers, flues, and boilers; also a number of furnaces have been insulated around the slag pockets up to the charging floor level; also around stack bases to protect the concrete from calcining and cracking.

With the exception of one small acid furnace, all new open hearth furnaces and a number of pits built in the United States in 1927, as listed by one of the leading trade papers, were insulated, and some seventy open hearths and pits have been built or are being built by more than twenty of the leading steel companies which are insulated with Sil-O-Cel materials. By the usual method of application, insulation reduces the radiation losses from sixty to seventy-five per cent, retaining this heat for useful work in the furnace. It prevents air infiltration due to the microscopic entrapped air cells. Our Standard brick is impervious to air penetration at a pressure as high as one pound per square inch; also, by reducing the outside temperatures of the heated surfaces, steel jackets are practical, which protect the walls and give added protection against air infiltration. In case steel jackets are not desirable, due to the difficulty of locating gas leaks, or extra expense, our brick are bonded between fire brick and red brick.

The results obtained through insulating are higher preheated air and gas temperatures, also higher temperatures to the boiler, faster, sharper working furnace, direct saving of fuel, high heat storage capacity during shut-down over week-ends. Mr. McMillan has pointed out the effect of insulation on a furnace due to reduction of radiation losses and prevention of air infiltration. A couple of other points may be mentioned, as prevention of brick spalling from too quick changes in temperature due to sucking cold air—especially through silica fantails—; also, eliminating the tendency for checker side walls to belly in, due to the fact that the insulation gives a more even heat gradient and uniform expansion through the brickwork.

The specification used by the Celite Products Company is about the same as that of the Johns-Manville Company as regards thickness. The insulation in the side walls and over the arches is very effective. However, in some instances, insulation in the bottoms of chambers and flues has been questioned. When proper consideration is given, it is seen that this application is important. The conduction of heat into the bottoms and surrounding ground is very high and also in most cases open hearth chambers have been built in the wettest places obtainable and the constant evaporation of water is a heavy drag on the furnace, as well as controlling the temperature in the bottoms of the flues and chambers. Insulation will also prevent calcining and breakage of the ordinary concrete mats under the chambers and flues. We have a concrete, which is recommended, is very strong mechanically, has good insulating value, is cheaper to install than its equivalent of firebrick, a thinner bottom can be used, and in one case allowed the same checker chamber volume, keeping the bottoms of the chambers six inches nearer ground level than had been figured on for a fire brick bottom. This concrete will not deteriorate in moisture.

The theoretical savings which may be made need not be discussed here, as the steel plant operator is interested mostly in proven dollar and cents savings per ton of steel, and time gained in open hearth is dollars and cents, just as much as reduction in fuel. There is, of course, another feature which enters, that the life of the brickwork is satisfactory. A number of furnaces have been insulated over the arches of the chambers, which is the thinnest and hottest section, for ten years, and while the life of a set of chambers should be twice this, there has been no indication that the insulation has any effect upon the life of the refractories.

One of the best open hearth superintendents in Pittsburgh district revamped some old furnaces which were in a line with identical furnaces. These furnaces melted steel on an average of fifty minutes faster per heat than the uninsulated furnaces, and the salvage of checkers was considerably higher from the insulated chambers than the uninsulated ones. This is attributed to the fact that a short, sharper working flame brought the boil nearer the incoming port and allowed more oxides to settle on the bath rather than being carried over into the chambers.

Temperatures were taken at various corresponding points on insulated and uninsulated chamber walls, at one of the middle Western plants. The uninsulated chamber walls showed a temperature average of 366 degrees Fahrenheit and the insulated, 191 degrees Fahrenheit, or a difference of 175 degrees Fahrenheit. The arch temperatures were not takn but would have shown a much greater difference in temperature. The insulated furnaces are 500 tons per month better than the uninsulated and they are now insulating parts of the old furnaces as repairs are made.

*Presented at Annual Convention of A. I. & S. E. E., June 27, 1928.

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In the Central District an open hearth plant was run with fuel meters on the furnaces for four months. An insulated furnace which is identical to the other furnaces with the exception that Sil-O-Cel brick was used to displace a course of firebrick, and steel jacketed, and our brick was used over the arches. The insulated furnace produced 8.3 per cent additional steel over the average of the uninsulated furnaces, with a fuel reduction of 2 per cent, and 18,000 B.T.U. oil at 3½c per gallon will repay the insulation cost in a year on this basis. The insulated furnace and one of the uninsulated furnaces were comparable, as they had been operating about the same length of time. By this comparison the insulated furnace produced 553 more tons per month on approximately 200,000 B.T.U.'s less fuel per ton of steel than the uninsulated.

Another plant reported an average increased efficiency of 7 per cent by insulating the chambers; also a saving of 52 hours' time in bringing an insulated furnace from cold to tap.

A furnace designed by Mr. Stevens, a consulting engineer of Chicago, and built in the Chicago District, is insulated with our product in the bottoms, side walls and over the arches, also the slag pockets, and is reported as having a very low melting cost per ton. This furnace, as is the case with most new furnaces, has new features included in its design and it is not the intention to claim too much credit for insulation, but rather to give the impression that, included with other improvements, it makes a good combination, one which returns the investment quickly and continues to make money over a long period.

Recently the chambers of an open hearth were insulated by placing a 4" thick reinforced wall of our concrete around the chambers applied with a cement gun. While there are no figures available yet as to results obtained, the application should be very satisfactory, as it is of monolithic construction, giving excellent air-proofing qualities, as well as good insulating value, and was surprisingingly low in cost to apply. It does not require a steel jacket, which is high in cost and difficult to make a good job on old chambers.

It was mentioned in Mr. McMillan's paper that it might be advisable to wait for rebuilding checker chambers before insulating the bottoms. We have insulated a number of bottoms when the checkers were taken out. The rider walls were simply removed and a course of insulation put into the base; it took very little extra time and it wasn't very expensive.

F. L. Ramsey*: Mr. Chairman: We have done very little in the way of insulating Open Hearth checker chambers, except covering the chamber roof with about 2½" of 3-C cement and giving the walls of the chambers a double coating of Hytempite and Silica Clay. This was done to overcome air infiltration. We were using a very rich mixture of gas and preheating it by running it through the checker chambers, and by taking gas samples in the up-takes, found that we were burning considerable gas. After putting the 3-C cement on the chamber roofs and giving the side walls a double coating, found that we had reduced the air infiltration to a minimum. It no doubt benefited us some on heat radiation through the roof of the chambers. Finding the benefit derived from this work, we have decided to go ahead immediately to insulate the checker chambers on our No. 1 Open Hearth Furnace. In addition to the insulating, we expect to encase the chambers in steel, and in probably six months, we would know what benefits are to be had from a furnace insulated against those that are not insulated.

From our own experience and what I have learned from furnaces that have been insulated, I believe that within the next few years, the majority of Open Hearth checker chambers will be completely insulated, as it would evidently be a great savings in fuel, and no doubt, the increased tonnage would pay for the insulation in a very short time.

A. Steed*: Mr. McMillan has given us very valuable information on the insulation of furnaces.

He credits the insulation with all of the heat retained in the checkers due to the reduction of radiation losses, but as the average gas temperature in the checkers is raised the stack temperature is also increased, especially so where there is no waste heat boiler.

We do not question that the improved furnace condition due to increased checker temperatures more than offset any increase in stack losses.

The question I have in mind is this: It is right to credit the insulation with the total radiation loss, and if any, how much is the stack loss increased?

A. J. Standing†: Mr. Chairman, one of my points of contact with the Open Hearth Department is in the Department of Waste Heat Boilers. I was interested in Mr. McMillan's discussion of insulation of furnaces, because the waste heat boiler is penalized, as our study showed, by the reduction of temperature of gases entering the boiler, infiltration of air, and by the cost of the boiler fan drive. Now, heat insulation is going to do two or three things. It is going to raise the temperature of the gas entering the waste heat boiler, it is going to reduce the amount of infiltration of air, and that automatically is going to reduce the fan load, which means a reduction in drive cost, which we must charge against the steam produced by a waste heat boiler. A waste heat boiler is quite a factor in the steam balance of most of our plants and I think the heat insulation, both on the checker chambers and on the boiler itself, which will accomplish the two things of excluding the air and raising the temperature of the gases, will materially reduce the size of drive necessary on the fans and give us a greater yield on the open hearth from the steam generated by waste heat boilers.

A. L. Foell‡: Mr. Chairman, I think that the data submitted by Mr. McMillan in his excellent paper will serve to show whether or not the insulation of existing open hearth checker chambers in any particular plant can be justified. It is thoroughly recognized on new installations that the insulation of checker chambers and other parts, where necessary, is worth while, for, all new installations have during

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recent years been insulated. On an old installation, however, or an existing furnace, particularly an open hearth furnace, the problem of insulating the checker chambers effectively and economically is not quite so easily accomplished. I have in mind, particularly the matter of preventing or eliminating air infiltration through the existing checker walls which are usually leaky. Unless the insulation can be properly bonded to the existing brick walls, it is somewhat difficult to prevent air filtration, the elimination of which is generally considered a vital and important function of insulation.

In insulating one of our open hearth furnaces at Donner Steel Co. we had in mind, aside from the prevention of heat loss through the walls of its checker chambers the matter of stopping all possible air infiltration. We therefore, proceeded first by sand blasting the entire exterior surfaces of the brick walls to be insulated for the purpose of removing all soot and other matter that had been deposited on the old checker chamber walls during previous operations and also to roughen these surfaces. We next proceeded by burning holes through the vertical buckstays about two inches from the face of the brick walls and about three feet apart vertically. Through these holes were inserted three-eighths or one-half inch steel rods somewhat longer than the horizontal center to center spacing of the buckstays.

These rods were spaced vertically, as I remember it, about three feet apart and continued around the entire chamber in ladder like construction between each set of two adjacent buckstays.

The rods provided a means for fastening wire mesh having four 14 gauge wires to the foot lengthwise and across the width.

The wire mesh was procured in suitable lengths and widths to fit the panels between the buckstays and was wired to the horizontal holding rods previously inserted into the buckstays. We then proceeded to apply the insulating material which consisted of a 4 to 1 mixture of Sil-O-Cal C3 and cement with a cement gun. The thickness applied was four inches over the entire surface. This method gave a very dense coating of insulating material and being shot against the sand blasted brick surface gave an adherence equal to, I believe, what is ordinarily obtained when concrete is shot against steel or other surfaces with the cement gun, and an insulation between buckstays that is all in one piece.

The checker chambers were insulated below the cellar line to a depth of about three feet. Over the top of the checker chambers a two or three-inch layer of Sil-O-Cel coarse was applied. This was simply laid over the arches loose.

It occurred to me that this somewhat novel way of insulating chambers might be of interest to the gentlemen present. The work on this furnace was completed about two or three months ago but the furnace has as yet not been placed in operation. I might add that while we used Sil-O-Cel material for the aggregate other insulating materials of a similar nature might perhaps be used with equal effect.

W. R. Chambers: I hold no brief for any of the devices that are on the market, because I have used all of them, we have applied them to furnaces that were in operation, to furnaces not in operation, and to new furnaces. I think this gentleman from the Donner Steel Company has gone to a little bit of unnecessary trouble. We have had some of our furnaces insulated while they were in operation, just taking the ordinary grade of brick, insulating brick, and we have also, where the outside walls and checkers have been uneven, as they often are, in a case like that we have just put a plate right across here and filled the whole thing full of powdered insulation or something like that. I don't know why these insulation manufacturers show a temerity in insulating rooms of checkers, they are always backing away from that. It seems like we have got to sort of push them into it. We have a number of furnaces operating with four inches of insulation, and by following the standard methods of insulating, we have no trouble at all.

As has been said here before, the insulation saving is so involved with other savings that it is hard to find. We have to calculate it from experimental data or something of the sort. But operating open hearth furnaces has become considerable of an art lately with the insulation and combustion control that Mr. Shadgen referred to. When you do those things, you get several results. First, you reduce the amount of fuel used and, consequently, you reduce the amount of flue gases which go overboard and cut down the erosion on your brick and you get a less volume of flue gases going overboard. While not changing the size of the checker chambers, you increase the efficiency of the checkers, and our experience has been that you do not increase your stack temperatures, in fact, you might reduce them.

J. H. McElhinney: Do you use waste heat boilers?

W. R. Chambers: We do have and we don't have.

J. H. McElhinney: It doesn't increase it where you do not have waste heat boilers, either?

W. R. Chambers: I think that most checker chambers on most furnaces, if they are operated with proper combustion control and insulation, are reasonably near large enough for the furnace. As we all know, if you work it through the combustion cycle, your stack temperature is around 1050 or 1100 degrees anyhow, it is impossible to get it lower than that, with insulation or any other means that may be brought in here.

J. H. McElhinney: Thank you, Mr. Chambers.

A. L. Foell: Mr. Chairman, I would like to reply to Mr. Chambers' comments to the effect that while we did go to a lot of trouble in this matter, we accomplished what we were after in obtaining absolutely air tight insulated walls. I am certain that we will eliminate all infiltration, providing this type of construction will stand up. I want to add also that the cost of this work was slightly over three thousand dollars and covered insulating the entire chambers of this furnace, which is making 100-ton heats, including also the slag pockets, and the chamber arches. I should like to hear how this cost compares with cost of other methods of insulating on similar furnaces.

Joseph F. Shadgen*: I am not directly interested in the matter of insulation and its bearing on the construction of furnaces, but indirectly I am interested in every phase of the combustion problem.

I want to call to the attention of the meeting one point which has not been brought out by any of the

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other gentlemen. Everybody looks at the b.t.u. side of the problem, but none looks at the man side of the problem. What influence has insulation on the efficiency of the man who actually runs and operates the furnace?

Everybody puts b.t.u.'s in dollars and cents. Everybody puts the raw material in dollars and cents, but we seldom put a dollars and cents value on the operating conditions which improve the efficiency and value of the human element. The man feature is responsible for the efficiency and the results, and there is very little doubt that insulation improves the man condition, and from that angle its value is very vital.

A. G. Witting*: Mr. Chairman and Gentlemen: I think we all agree on the principle of insulation and that those who have tried it have gotten practical results which are satisfactory. To translate these results in dollars or in fuel saving I consider, however, an impossibility. As Mr. McMillan pointed out, there are so many factors influencing the fuel consumption, and any one who thinks he can ascribe a certain saving to this or to that, is as a rule mistaken. But I do believe, from our experience, that it is possible to give the insulation some credit for decreased time of the heat, which naturally means a saving in fuel. It is also without doubt a fact that you can credit the insulating for a gain in waste heat for the boiler: i. e., increased steam output, although other conditions may have influenced such gain.

With regard to air infiltration, the insulation with steel plate jackets will considerably help to prevent it; but infiltration can to a large extent be overcome by other means. For my part, I believe that infiltration is to a larger extent taking place in the uptakes than in the checker chambers, not to mention the furnace doors. We have given considerable attention to this infiltration and have succeeded in bringing it down to be a negligible factor by the application of an elastic putty. We have run a series of tests and found an oxygen content in the waste gases between 1.2 and 1.9% and never over 2%, which can pretty well be considered to indicate perfectly tight walls, as such a surplus of air is required for complete combustion.

We have a couple of furnaces in which the checker chambers have been insulated, but we have not carried the insulation below ground. Tests didn't show such temperatures in the filling around the chambers that would appear to warrant the considerable increased cost of insulation below the floor. If you build a new furnace, conditions are different and you would, of course, insulate all around, even the bottom. It may be possible, as Mr. Kennedy said, to put in bottom insulation when a furnace is rebuilt, and it might be a paying proposition if the ground around the chambers is wet. But that means tearing out much more of the checker work than you ordinarily do.

There is another side to the question of insulation, viz: how it affects the life of the checker brick. There is no doubt that the temperature in the checker chambers is considerably increased. What influence this higher temperature has on the brick will have a bearing on the question whether insulation actually pays. Our furnaces have not yet completed a campaign so that we can not yet answer this question.

In summing up I would say that, although the effect of the insulation cannot be definitely expressed in time gained or fuel saved or increased steam production, the indications are that gains have been made and that they undoubtedly make the expense for insulation worth while.

D. S. Hays: The value of insulating checker chambers of open hearth furnaces is readily seen by the following example of a recent installation. During the year 1927 I completely rebuilt five 100-ton furnaces of the same design, the only difference being that I insulated the roofs of the checker chambers of one of these furnaces and put nothing on any of the others. During the first six months of this year the furnace with insulated checker roofs made 8% more tonnage than the average of the other four and 10% less fuel than the other. I believe this to be due, not only to keeping more heat in the chambers and returning it to the furnace, but to the fact that the insulation made the chambers air tight, making it necessary for all air to enter at valve saucers and traveling entire length of checker and flues. I believe that without an air tight chamber a considerable part of the air is drawn into chambers at furnace end and gets very little preheat. Naturally any infiltration through checker roofs would allow air to pass directly to the furnace without going through checker work, and the heat from previous reversal would not all be returned to the furnace. In the case of waste heat boiler installation it has been my experience that more steam is generated on account of increase in stack temperature which in turn is due to the decrease in heat from radiation. I firmly believe that the cost of insulating checker chambers is soon paid off by reduced fuel costs and a sharper working furnace. My experience has also shown a more even distribution of fuel dut in checkers which is due, I believe, to a more uniform distribution of waste gas through the chambers.

J. H. McElhinney: Before Mr. McMillan takes the floor, I might say that at Lukens we had two very old furnaces which seemed to be beyond further repair and we took them clear down to the ground. They are of the same size, they are right beside each other, use the same kind of fuel, make the same kind of steel. One we are insulating and the other we aren't. Maybe by the time another meeting occurs, next spring, Mr. Conway can give you some comparative information that will be interesting.

Mr. McMillan, will you answer these question that have been asked, please?

L. B. McMillan: The interest shown in this paper and the constructive discussion have been highly gratifying and especially so because of the unanimous agreement on the beneficial results accomplished by the use of insulation on checker chambers. Likewise, the extensive experience represented by the discussions has confirmed the statement made in the paper that with suitably designed insulation the earlier fears as to possible ill effects on refractories were unfounded.

In replying to the discussions, I shall answer first the direct question brought up by Mr. Steed as

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to whether or not a part of the saving attributed to insulation may go into increased stack losses. In answering, three phases of the situation must be considered separately. First, if there are no waste heat boilers, the stack temperature will usually be increased by insulation, but with decreased infiltration the weight of stack gases will be less so that there may be not only no increase but actually a decrease in the total stack loss. Second, if there are waste heat boilers, the effectiveness of these is improved by the higher temperatures of the gases from the checker chambers. Third, if both the effects on infiltration and on waste heat boilers are left out of consideration (and in no practical case can the question of infiltration be left out), the method of evaluation of savings outlined in the paper still applies. The item on value of heat always takes into account the availability of the heat for doing useful work. If all of the heat saved were not utilized, then a lower value of heat per million B.t.u. would have to be used in the computations. But on the other hand, in this connection one must not lose sight of the fact that high potential heat is much more valuable than low potential heat. Therefore, the utilization of a portion of the heat saved to increase the potential of the entire amount of heat delivered by the regenerator may represent more effective utilization of this heat and give it greater value than if all of the heat saved were utilized at lower temperatures.

Mr. Kennedy brought out two important points: the fact that insulating the walls made it more readily possible to seal them on the outside by means of steel jackets or some other means, and that the bottoms of chambers of old furnaces may be insulated without excessive cost at the time the checkers are renewed. However, his suggestion as to the possibility that steel jackets are less desirable from an air leakage point of view than insulating bricks laid between fire brick and red brick is open to question. The bricks themselves may be relatively impervious to air penetration, but the same can hardly be said of the joints.

Referring to Mr. Witting's comments on the insulation of the below ground portions of regenerators, I will frankly state that it was not so long ago that I, myself, felt that the insulation of such portions might not be justified. However, the more the problem is studied, taking into consideration the amount of heat required to raise the temperature of the surrounding earth and the amount required to evaporate the moisture entering the dry zone around the regenerators, the more it becomes apparent that insulation on the bottoms and side walls below ground is thoroughly justified in the case of new furnaces. Mr. Witting also stated, however, that this would be their practice on new furnaces.

Of the other comments on additional advantages secured through the use of insulation, Mr. Hays' comments on the effects of insulation on the operation of the furnace, Mr. Standing's remarks on decreased fan power due to reduced air leakage and Mr. Shadgen's comments on the influence of insulation on the efficiency of the man who actually operates the furnace are most timely and important. Insulation on furnaces provides improved working conditions for the attendants and improved working conditions make for improved efficiency, which is sure to result in better and more economical operation. The vital importance of insulation as related to human comfort and what this means all along the line has been given all too little attention in the past.

AN ODE FROM THE OPEN HEARTH

Taken from notes on file by MARTIN J. CONWAY

Did you ever stop to think as you speed on a train, how the rails that you ride on are made?
We'll listen to me and I will tell you, for this knowledge will be of great aid.

The first move made is to put in the lime, and then follow up quick with the scrap.
Letting the whole mess cook for awhile, as the first helper is taking his nap.

Then grab the poor kid by the back of the neck, starting him off with a shout,
"Get the hot metal here, what the hell do you think? That this one will never come out?"

Once more the first helper goes back in the nay with a long drawn sigh of content
While the kid throws her over just once in a while as though all his energy was spent

Then she seeths, boils and froths and foams, like a storm on the ocean's floor,
Till the first helper jumps up with a curse and a shout and yells "let's give her some ore."

Then follow on with a little fluor spar and the steel is all ready to pour,
The gang is all here, the rod is picked up and poked through a hole in the door.

Two or three mighty thrusts and the steel rushes out with a roar and blinding flame,
"Throw the manganese in," yells the melter in rage, "do you want me to get all the blame?"

Then over to the stage where the steel pourer stands and with many a splash and spill,
The moulds are at last filled with the white hot stuff and the heat is all ready for the mill.

Then down to the pits for a three hours' rest, then into the jaws of the rolls,
Where backward and forward with many a crack, it goes to its final abode.

As she rises and falls to the pound of the rolls, taking shape all the while as she goes,
And at last comes out with the web and ball as smooth as a polished floor.

Then away to the saws where the red sparks fly and the noise dies down to a hum,
The rail is complete, the inspector is next, the dog gone son of a gun.

*Symposium—Anti Friction Bearings For Electric Motors, Auxiliaries, Roll Necks**

DISCUSSION

DISCUSSION ON BEARINGS

W. L. Poto†: I think Mr. Murray covered the subject pretty completely, but I want to add that the first bearing which we installed to replace M C B bearings on cranes was just a few years ago. Now they are used on 25 or 30 per cent of all our cranes. On crane work we feel that the power saving is not so important as the saving in maintenance and lubrication, as on some motions the additional plugging and braking tends to overcome the benefits of power saving.

We agree with Mr. Murray that the important features on anti-friction bearing installations are to have the bearings amply large and properly installed.

D. E. Batesole‡: Mr. Chairman and Gentlemen: There is very little that I can add to the discussion. I believe we can get better results by having some of the steel mill operators tell of their actual experience.

As for Mr. Waldorf's paper, our experience thus far on roll neck applications made abroad have shown savings of about 35 per cent, or figures closely approximating those given by Mr. Waldorf. I believe that when we are considering the power saving to be accomplished by changing sleeve bearings to roller bearings, we should look into the design of sleeve bearing to be replaced, its size and proportions as compared to the load it must carry, and also the nature of the service which it must undergo, whether continuous or intermittent. The friction of a sleeve bearing will of course be greater where the shaft is not in continuous rotation, especially if the load is heavy. Under these conditions we can expect a great saving in power by applying roller bearings. On the other hand, some of the modern day sleeve bearings have been very well designed from the standpoint of bearing proportions for the load applied, and of lubrication, so that the savings effected by replacing such bearings will not be so great. It behooves the engineer, therefore, to look into the nature of the bearing which is to be replaced so that he will be sure of the power saving which the change will bring about.

In the steel mill, however, the sleeve bearing is, as a rule, improperly designed on account of limiting dimensions, difficulty of lubricating, etc., so that the use of roller bearings will, with the possible exception of the steel mill motor, afford a distinct saving.

W. L. Iliff§: I don't believe there is very much that can be added to the papers that have been presented on the subject of roller bearings for mill and crane motors. There is one point that has been frequently asked and that is with respect to lubrication. How often do we consider that roller bearings on these motors should be lubricated. That will depend a great deal on the nature of the service. On inquiring around among the mills, we find that six months is a pretty fair mark to shoot at on the average. There are installations where a year is ample time for lubricating. On the other hand, there are certain installations where the nature of the service is such that three months would probably be a safer mark.

The kind of lubricant that is being used is an important item. We find that a soft grease, about the consistency of a vaseline, is the correct lubricant to use, with our type of bearing, at any rate. The character of this grease should be such, however, that the lubricant in the grease does not separate from the filler. You will find that there are some greases where the lubricant will separate from the filler under the action of a compression gun or cup. There are lubricants, however, which will not separate in this manner and they are the ones that should be chosen.

The detail as to the nature of the grease and the kind of grease would better be left to a lubrication engineer, who can advise you and give you the right grease for your particular service.

E. C. Gainsborg*: It has been mentioned in one of the papers read that it was of utmost importance to know the magnitude of the pressures which occur at the roll necks, before you can determine the size of anti friction bearing which should be used. It was further added that there is no basic data on that subject and that the burden of this task should fall upon the shoulders of the Steel Mill Engineer.

As a result of experiments conducted by our company, SKF Industries, both here and abroad, independent of each other, we have been able to arrive at a method whereby we can determine the existing pressures during the process of rolling. As far as we can tell, these determined values fall within 10% to 15% of the actual loads, which we consider close enough for practical purposes. We have developed formulas and have checked them against practical tests, the results are indicative that it is possible to predetermine roll neck pressures, providing one knows (1) **roll barrel diameter,** (2) **RPM at which the roll is rotated,** (3) **width of stock passed,** (4) **actual draft or reduction,** (5) **temperature of the material at the time of pass,** (6) **composition of material rolled.**

Last year at our Annual Meeting, I explained that to obtain roll neck pressures on plain bearing mills, during the process of rolling, we resort to a very simple method. A cylinder of about 3½" in length and 2" in diameter, made of ball bearing steel harden-

*Presented at the Twenty-fourth Annual Convention of The A. I. & S. E. E., at Chicago, Ill., June 28, 1928, by E. S. Jefferies, J. S. Murray, J. H. Van Campen and Fred Waldorf.

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ed throughout, is inserted between the screw-down and the upper cap of the upper roll of the mill; to the steel cylinder is attached a modified form of Strain Gauge and, as the pass goes through, the cylinder is compressed; of course, the load imposed must not transgress the elastic limit of the cylinder.

A dial, which is a part of the Strain Gauge, registers by a needle a certain number of divisions which corresponds to the pressure imposed. The Strain Gauge, having been calibrated on a Universal Testing Machine for corresponding values of load, enables one to derive a curve and from it obtain directly pressure values which occur during the process of rolling.

SKF has tabulated pressure readings on different type mills and from data collected has been able to check developed formulas. Roll neck pressures obtained by test and values derived by formula are approximately the same.

On certain type mills where the upper roll is held on a rider, and the draft is accomplished by adjusting the lower roll, our experience shows that the initial screw-down pressure may be of a magniture almost equal to the pressure imposed at the necks during the reduction of the material passed. In other words, for illustration purposes, I will briefly outline the results had on a Bar Mill equipped with plain bearings.

The cylinder was inserted underneath the screw-down and the mill operators were allowed to sledge the screw as customary during the process of rolling. The Strain Gauge was attached to the cylinder, dial set to zero, and 14 or 15 passes sent through. The pressure per neck, during the process of rolling, as indicated on the dial of the Strain Gauge, was of a magnitude ranging from 95,000 to 105,000 pounds per neck. The dial on the Strain Gauge was then checked for zero and the screw-down backed off. We found that the initial screw-down pressure was between 75,000 and 85,000 pounds. In other words, had the test for pressure been taken by the conventional Brinnell Method, of inserting balls between two hardened plates and from the impressions determined the prevailing pressure, the actual values would have ranged from 160,000 to 190,000 pounds per neck.

It is evident the problem is not simplified if we attempt to provide for a load of 160,000 pounds as against 95,000 pounds? It is not unlikely that under such conditions we might have had to abandon the possible use of anti friction bearings.

Going further along into this subject, our experience indicates that the maximum load is not the criterion on which the bearing should be selected, but rather on the basis of an intelligent understanding of the average load condition; for as we all know, the mill operator at one time may be running stock of a certain width and at another time the width may be greater or less and the same thing applies to the actual draft or reduction of material, at different times.

We find that we must reduce the variation in width and draft to some average value, in order to arrive at a satisfactory conclusion as to the size of bearing which should be used on any specific mill application.

Anti friction bearings have the same characterististics as electrical motors, insofar as their ability to carry considerable overload with no detrimental effects, if it does not occur too frequently or if it does not occur for a long duration of time. This condition indicates the importance of knowing the actual rolling pressures and the fallacy of attempting to ascertain pressures by the Brinnell Method.

I might mention in passing that our company is in a position to inform the prospective bearing purchaser as to the period of life, measured in hours of service, which may be expected from a certain bearing selected. In other words, from figures obtained in our laboratories, here and abroad, having run some 10,000 to 15,000 bearings to destruction, covering a period of over 10 years and which tests are still in process, we have from the information collected developed life curves which are not unlike, "Insurance Company Mortality Curves on Human Life." These curves as far as we can tell may be applied to any anti friction bearings, provided that certain factors be known. Curves developed in the early years of the test showed that the percentage of bearings which we might describe as having died at infancy, were greater than our judgment would have indicated. This knowledge has enabled us to investigate causes responsible for the loss of bearings in the early stages and by improved methods of manufacture prolong their period of service, setting the average range of life at a higher plane.

If one is to select a bearing and determine theoretically, from the size and number of rolling elements contained, its carrying capacity if it be 100,000 pounds or 1,000,000 pounds, the value is meaningless; it is not the theoretical static carrying capacity of bearings about which we are concerned but rather the rate of dynamic usefulness, which can be reduced in simple terms of prevailing pressure and RPM.

I might for comparison purposes offer the following as an illustration: a bearing is selected to meet certain conditions of pressure at a definite RPM; what period of time in hours of service should elapse before the usefulness of the bearing shall be consumed? It all depends upon the rate at which the RPMs are consumed and not upon the initial theoretical carrying capacity. A man may earn $10,000 per year and save nothing at the end of the year; whereas an individual earning $2,000 a year may save $200 or 10%—it is the rate of spending which tells the story.

In connection with our research work on bearing life we found an interesting relation between pressure, RPM and life of the bearing. For example, assume that we take a bearing of a certain size and subject it to a load of 10,000 pounds at 500 RPM and predtermine a life of "X" years, continuous service. If we halve that load or halve the RPM, the life of the bearing does not increase two-fold as we might assume, but instead it has increased ten times, that is "10 X" years. You can see the importance of this relation and the reason the anti-friction bearing manufacturer endeavors to obtain a reduction in roll neck diameter, or an increase in barrel diameter, so as to effect an increase in bearing size; even though it be only a fraction of an inch, because that small addition is reflected in a material increase in bearing life.

By the same token if we select a bearing to carry a load of 10,000 pounds of 500 RPM and a load or speed be doubled, the life of a bearing is then reduced to one-tenth of the original value.

Mr. Waldorf's paper on Power Saving endorses our own investigations conducted here and abroad. In fact, an average of 35% power saving is a modest value. Our experience and our conclusions would indicate 45% to 50%, representing a better average. There is no other type of installation of which I know of in any other industry, where the possibility of power saving stands out as it does on roll neck applications. We can start out on the basis of a 40% saving, but I dare say that in the majority of cases it will be considerably greater.

Temperature is most important and effects the roll neck pressures to a greater extent in certain ranges than others. A difference of 100° in temperature above 1900° to 2000° F. does not mean as much as in the roll neck pressure as a difference of 75° below 1900° F. The lower the temperature the higher the pressure. Of course, undoubtedly there are certain conditions in the art of rolling steel which make it necessary to keep the heat of the metal within certain ranges. Though the anti friction bearing manufacturer would like to have the higher range in temperature, we must abide by the limits which prevail in practice.

In conclusion, I shall again repeat that, having a knowledge of the barrel diameter, RPM of roll, width of stock, amount of draft and temperature of material, it is possible to predetermine the intensity of terial, also kind of material, it is possible to predetermine the intensity of load which shall occur at the roll necks.

J. H. Van Campen*: In referring back to Mr. Gainsborg's remarks as to increase of pressure due to temperature changes in rolling steel, there is an old rule that for each drop of 400° F. in temperature under approximately 1800° F the power requirements are doubled.

There is another problem in applying roller bearings to roll necks which our Company is very much interested in, being builders of cold rolling mills in particular, where the tolerances are extremely close on the finished product. And that is the amount of eccentricity within the bearing itself.

It is a very vital question with us to get bearings that run absolutely true to roll steel within a tolerance of one-quarter of a thousandth of an inch, which means a very accurate roll neck anti-friction bearing.

Therefore, I would like to ask the representatives of the various bearing companies who are here today what they consider the limits to be of an extremely accurate bearing in reference to eccentricity within the bearing itself?

E. C. Gainsborg: Answering Mr. Van Campen's question regarding eccentricity and its relation to the thickness of material rolled, we should consider the eccentricity of the inner race of the bearing rather than the eccentricity which exists between the inner and outer races.

How does the eccentricity of inner race occur and let us define it: take for example a deep groove ball bearing or, better still, suppose we consider the inner race of a Norma Hoffman type bearing, the roll path of which is to be ground; my selection of that type of bearing is without any reflection because we also manufacture it. The ring for the inner race is mounted on an arbor and locked against a shoulder. Naturally, the bore of the ring must be of a larger diameter than the diameter of the arbor. The difference in these two diameters introduces the value of eccentricity on the ground surface, which is measured in the fourth decimal place. For all practical purposes, when you consider roll deflection, also deflection in the mill housing, in our judgment the actual amount of eccentricity which exists in the inner race of the bearing is not of sufficient importance to be taken into consideration; I do not believe it effects the uniformity of section passed.

L. A. Umansky*: I am very glad to be called upon by the Chairman to comment on the use of roller bearings on electric motors used for main roll drives. I have heard of late a number of questions, running like this: "If roller bearings are used to such a great advantage on mill stands, why not use them on motors which drive these mills?" A proper answer to this question may be given if we analyze the advantages that can be derived from a roller bearing in either case. The principal advantage of roller bearings, as used on roll necks, is the very appreciable saving of power required to roll the metal. The mill bearings are taking a tremendous radial thrust when the metal is reduced in size while passing through the rolls; the roll neck friction comprises a very appreciable part of the total work previously called "net rolling work" and it is quite natural that the use of roller bearings has reduced the power consumption by 30-35% and, as some claim, by almost 50%.

Now, if we consider the motor bearings, the only radial thrust that is involved is that produced by the weight of the motor armature. The bearing friction, even when sleeve bearings are used, is well within 1% of the motor rating and no one should, therefore, expect any such spectacular saving in power consumption like 30-35% if roller bearings are used with the motors; all that can be saved, if anything at all, is the fraction of 1%.

Thus we may eliminate entirely the question of power saving in discussing the roller bearings on main roll drives. The problem is simply this:

A. Do the sleeve bearings, as used on main roll drives, give an appreciable amount of trouble?

B. If so, will the use of roller bearings eliminate this trouble?

C. If this is done, will not the roller bearings introduce some difficulties which more than outweigh any possible advantages?

We are well aware of the oil troubles and resultant motor failures which were the principal factors why the roller or ball bearings are so widely used on mill auxiliary motors and on many general purpose motors. We all realize that with these small motors of compact design it is next to impossible to prevent a careless or a too zealous motor inspector from appying an abundant supply of oil, not only to the motor bearings, but to the motor armature and commutator as well. The use of roller bearings seems to have cured this trouble and those operators who have tried this remedy will hardly go back to the sleeve bearing motors.

The large main roll drive motors are usually more carefully inspected, are far less crowded and,

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*Engr. Dept., General Electric Co., Schenectady, N. Y.

therefore, are much more seldom over-oiled than the auxiliary or general purpose motors. In fact, we very rarely hear of, and you very seldom have any troubles from this cause so that there is much less inducement to consider roller bearing application for these large units, although there is no good engineering reason why successful roller bearings could not be designed and applied to many large d-c. or a-c. machines.

The principal objection to their use is again not from the manufacturing but from the operating end. Roller bearings can not be, of course, readily built of the split type, as the sleeve bearings are usually designed and, therefore, whenever a bearing has to be changed the mill coupling must be pulled off. Now, this is quite a job, requiring suitable facilities not readily available at many mill motor rooms. When such a coupling is removed, it is rather difficult to obtain a good fit after it is pressed-on again, not to speak of the time and trouble required for this operation. When the sleeve bearing must be changed all you have to do is to take the cap off the bearing pedestal, take the weight off the bearing and quickly change the bearing shell.

While I do not want to be understood as discouraging the use of roller bearings on main roll drives, it will be well to remember that the advantages are not as evident and the disadvantages are more pronounced than is the case with the auxiliary and general purpose motors.

A. J. Standing*: We have no applications of anti-friction bearings on mill drives, but we have a great many individual auxiliary motor drives. In the past two or three years all the motors that we have bought have been anti-friction bearing motors, and at the same time we have been going over the most outstanding trouble makers in the plant with the thought that we would cure those motors which our records show repeat themselves from bearing troubles or armature troubles attributable to oil or bearing defects, with the result that we started on screw-downs and mill tables and the hardest service jobs. There are a great many motors in our plant which we find never show up for trouble in the period of five or six years, and we let those motors alone without spending a cent on them, but continue our application on the repeaters which come into the shop most frequently and watch our armature rewinding and repair curves and see what we accomplish, because the installations we have made so far are so outstandingly successful. It happened that the first application of roller bearings was to a screw-down motor on a 46-inch blooming mill which our records showed repeated itself from a bearing failure in the neighborhood of every two weeks, and the first anti-friction job was in ten months, at the end of which time we took it out for inspection.

Now, we don't expect the relative life on all our jobs to be that good, but that convinced us that we had so much to gain that it was worth while going through the shop expense of making the installation.

R. M. Hussey*: Mr. Chairman, like Mr. Standing has done, we have equipped a great number of the more troublesome motors, both general purpose and mill type motors, with anti-friction bearings, with very gratifying results, in the last couple of years, and practically every new auxiliary motor that is purchased now comes through with anti-friction bearings.

Mr. Poto, I believe, did not make much of power saved on cranes, and I believe that not very much can be made of the power saved on cranes except, maybe, on the bridge drive,—and I will refer again to bridge drives, which we have described before in one of the recent issues of the Iron and Steel Engineer.

We have two cranes of the same size, the same capacity, working under the same conditions, on the same runway, one crane equipped with anti-friction bearings on the bridge drive, the other crane equipped with sleeve bearings; the anti-friction bearing bridge drive having 65-horsepower in motors driving it, and the sleeve bearing crane having 132-horsepower in motors driving it, yet the lower-powered anti-friction bearing crane runs fifty feet more per minute under load than the sleeve bearing crane with twice the horsepower. There is a case where there is some saving in bridge drive.

*Elec. Supt., Saucon Plant, Bethlehem Steel Co., Bethlehem, Pa.

*Elec. Supt., Jones & Laughlin Steel Co., Woodlawn, Pa.

PHILADELPHIA DISTRICT SECTION

- OUTING -

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Manufacturers Country Club, Oreland, Pa., on Limekiln Pike, three miles northeast of Glenside.

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A. I. & S. E. E. JUNIOR DIVISION

(Devoted to practical problems of electrical department employees in the Iron and Steel Industry)

GLOOM AND GLARE VS ILLUMINATION*

IN this series of articles on lighting, two fundamental factors which are enemies of vision, will be mentioned frequently. Their names are **gloom** and **glare,** and they appear in many guises. The presence of one or both are certain indications that vision is not as it should be—quick, clear, and without strain.

The first is gloom, which, as every one knows, is the lack of light, or dimness. It represents the characteristic of illumination which causes the eye to strain itself to see details.

The eye is capable of adapting itself to see under illumination which ranges from a small fraction of a foot-candle to several thousand foot-candles. Under very low illumination the eye does not receive sufficient light to enable it to distinguish color or detail, and under unusually brilliant sunlight a blinding effect which also obliterates detail is experienced. Between these limits there is a wide range where good vision is possible.

The fact that the eye can function under low illumination often causes undue fatigue, since the eye receives warning only after a long time has elapsed, generally after the mischief is done.

Every time the eye is forced to accommodate itself to a change in the level of illumination (foot-candlage) high to low or vice versa, certain of its muscles are exercised. Sudden and constant continuation of such changes produce fatigue; ultimately, eye defects. One other phenomenon that has to do with industrial efficiency in lighting is in the fact that the eye takes time to adjust itself when the light changes. A constant quantity of light is, therefore, desirable; changing the foot-candle level materially disturbs vision and is deceiving. This misleading impression often gives rise to argument about the amount of light necessary for various applications.

Coming out of a theatre into daylight may give the impression that the theatre lobby was dim, yet you may have been able to walk out of the building without trouble. Even the light from a match, in a clothes closet, may be sufficient illumination for a few seconds; the amount would be unbearably insufficient for steady work in tin-plate sorting, for example. For the latter application the illumination must approach the level of 25 foot-candles. In a foundry the range should be on the order of 8 to 12 foot-candles. One-half foot-candle is sufficient for railroad yards and certain storage areas. We may conclude, therefore, that the illumination needed depends on what kind of task we ask our eyes to perform.

*Prepared for the Junior Division of the A.I.&S.E.E. by K. A. Staley, Illuminating Engr., National Lamp Works of the General Electric Co.

LIGHT-MEASURING INSTRUMENTS

Since the amount of light we need depends upon the kind of work required, it is first of all important to have a method of calculating the quantity of light. The perfection of light-measuring instruments takes the guesswork out of determining how much light is present. Once the amount of light is produced under which the eyes can function best for a given task, and the value read on a meter, it only remains to reproduce that amount of light (consistent in quality also) in other departments where the same kind of work is being done, to obtain similar working results.

FIG. 1—The pupil of the eye contracts when a glaring light source is present, and expands when the light is correct.

The instrument in most common use for measuring light is the foot-candle meter. It measures it just where the eye sees the object during work, such as the tool-point on a lathe, or the end of a plate between rolls.

The instrument is very simple to operate, it is so light that it can be easily carried about, and it is so small that it can be used in very restricted places. Readings can be taken in practically any place about mill machinery where the operator must look.

FIG. 2—The foot-candle meter should be a part of the electrical apparatus of the steel mill.

In operation, the foot-candle meter is placed upon or adjacent to the surface on which a measurement of the footcandlage is desired, the voltmeter

needle is brought to position, and the reading taken. Referring to Fig. 2, a small incandescent lamp concealed within the box at the right end of the screen illuminates the translucent spots on the screen to a high intensity at one end and low at the other. If the illumination to be measured falls within the limits of the meter (0.1 to 100 foot-candles) the spots will appear bright on one end and dark on the other. At the point where the spots are neither brighter nor darker than the paper scale, where the spot seems to fade into the scale, the illumination from without and within are equal, and the foot-candles of illumination can be read directly. "One tenth" and "double scale" are provided. Energy

FIG. 3—The eye constantly battles against the glare from a bare lamp, but the lamp always wins.

is supplied by a small flashlight battery. Every steel mill electrical department should be equipped with one or more meters.

GLARE

A Pronounced Evil

Glare is defined as an annoying brightness in the field of vision. Look directly at a lighted lamp and then try to see the socket just above it. For a split-second, you cannot see it, the nerves of your eyes are paralyzed. If you had to do that many times a day for a month, you would probably become blind. Many installations in steel mills are similarly glaring, though in a lesser degree. When bare incandescent bulbs hang near the eye, all the bad effects of glare are present. The eye fights against them constantly, but **ultimately the lamp wins.**

When the eyes are in darkness or semi-darkness, the pupils expand as shown in the left illustration, Fig. 1. When a bright light source, such as the sun, or a lamp filament, shines into the eye, the pupil contracts to a pin-point size. This is Nature's way of shutting out excessive light; the eye acts exactly as a camera, for bright objects and backgrounds the shutter is closed up so that only a small aperature remains. Similarly in dark surroundings, the pupil expands to let in more light. Thus when there is a very bright object in the field of view, such as a bare lamp, the pupil expands to allow light enough to enter the eye, but at the same time it tries to close up the pupil so as to cut down the excessive light from the brilliant source. This multiple contraction and expan-

FIG. 4—The R L M Standard Dome and white-bowl lamp is the most widely used reflector and lamp combination in the industry.

sion, opposing forces, causes eye-strain, frowning, etc., and represents one of the signs of poor lighting that is unmistakable and usually easily detected.

A Modern Evil

The problem of overcoming glare was not very serious in the days when carbon-filament lamps were used, the lamps themselves were not very bright and the glare was neither particularly harmful nor annoying. But as lamp manufacturers made better light sources and the Mazda C gas-filled lamp replaced the carbon, Gem and Tantalum (along with arc lamps) it was apparent that something had to be done to reduce the glare encountered from the brighter filaments. With the new lamps, single

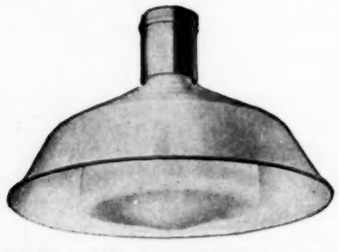

FIG. 5—Glassteel Diffuser units combine a glass globe with the steel reflector. The unit is especially applicable for fine inspection and drafting rooms.

bulbs giving three to four times as much light, there was a definite need for shades that would keep the glaring source out of sight, and some means of softening or diffusing the extremely bright sources.

The "tin cone" shade, as a means to overcome glare, was the forerunner of modern reflecting equipment. Not only did the light source prove less annoying, but with a good inner reflecting surface such as white enamel, the light obtained on the work was greatly increased. The shade magnified the light just as a megaphone magnifies the voice.

A number of developments which followed are shown in Fig. 3.

One improvement in lamps, which was very successful when combined with the new type reflectors, was coating the bowl of the lamp to cut out direct view of the filament. At first, mirrored-surface caps were attached to the lamp, but this was soon replaced by an enamel coating of the lamp bulb. White-bowl or bowl-enameled lamps today, when combined with a standard enameled steel reflector, mark the most widely used reflector and lamp combination in the industry. (Fig. 4.) The coating on the lamp transmits a small part of the light, without producing excessive brightness or harmful glare. The greater portion of the light not so transmitted is thrown upward to the surface of the reflector and from there returned to the working plane as diffusely reflected light. The enamel produces a smooth durable surface which can be readily cleaned.

Lighting glassware, such as prismatic and white-glass globes, to overcome glare and provide diffused light, has been developed for all types of service in interior and exterior lighting for steel mills. Glass globes have also been combined with the enameled steel reflector, as in the Glassteel Diffuser (Fig. 5.) This unit has a metal reflector similar to the RLM (Reflector and Lamp Manufacturers') Standard Dome, combined with a white-glass globe which completely surrounds the lamp. Flutes in the top allow a small part of the light to escape upward to illuminate the ceiling and thus improve the appearance of the room. The Glassteel Diffuser may be used with 150-watt to 1000-watt lamps. This luminaire is particularly applicable for fine machine and bench work, inspection of tin plate, mill offices, and drafting rooms. The use of enclosing glassware, high bay units, and other types of equipment will be taken up in another article.

With the development of larger, more powerful lamps came the standardization of sizes and types

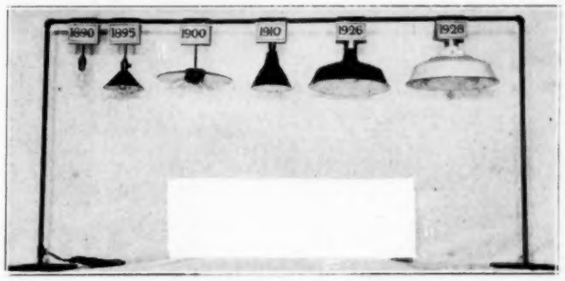

FIG. 6—As better light sources were developed, types of equipment were developed to produce glareless illumination.

of reflectors for industrial and commercial installations, until today practically any lighting requirement can be met by the application of standard equipment. The obvious advantage lies in lowered cost of lighting to the mill owner, coupled with increased accessibility to the advantages modern lighting brings.

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(Continued from Page II)

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Fred Waldorf, Engr., Timken Roller Bearing Co., 119 Gould Ave., Pittsburgh, Pa.
D. E. Batesole, Norma Hoffman Bearings Corp., Stamford, Conn.
H. R. Reynolds, Fafnir Bearing Company, New Britain, Conn.
Samuel Farrell, Rollway Bearing Company, Pittsburgh, Pa.
J. S. Murray, Elec. Supt., Follansbee Bros. Co., Follansbee, W. Va.
R. L. Brown, New Departure Mfg. Co., Bristol, Conn.

ELECTRICAL DEVELOPMENTS COMMITTEE

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Main Roll Drives Division

O. Needham, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
J. D. Wright, General Electric Company Schenectady, N. Y.
R. W. Davis, Allis Chalmers Mfg. Co., Milwaukee, Wis.
W. H. Feldmann, Electric Machinery Mfg. Co., Minneapolis, Minn.
A. C. Bunker, Crocker Wheeler Elec. Mfg. Co., Ampere, N. J.

Auxiliary Drives and General Purpose Motors Division

A. M. MacCutcheon, Reliance Elec. & Engr. Co., Cleveland, Ohio.
J. R. Lewis, Crocker Wheeler Elec. Mfg. Co., Pittsburgh, Pa.
J. C. Barry, General Electric Company, Erie, Pa.
D. W. Deans, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
W. H. Powell, Allis Chalmers Mfg. Co., Milwaukee, Wis.
J. S. Lincoln, Lincoln Electric Co., Cleveland, Ohio.
H. S. Stockdale, Electro Dynamic Co., Pittsburgh, Pa.

Control Division

N. L. Mortensen, Cutler Hammer Mfg. Co., Milwaukee, Wis.
W. H. Williams, Clark Controller Co., Cleveland, Ohio.
R. G. Widdows, Electric Controller & Mfg. Co., Cleveland, Ohio.
L. A. Umansky, General Electric Company, Schenectady, N. Y.
E. B. Newell, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Joseph F. Frese, Asst. Chief Engr., Monitor Controller Co., Baltimore, Md.
J. S. Rowan, Rowan Controller Company, Baltimore, Md.

Crane Division

G. W. Yanney, Alliance Machine Co., Alliance, Ohio.
F. H. Barnard, Morgan Engineering Co., Alliance, Ohio.
F. J. Brittingham, Cleveland Crane & Engr. Co., Pittsburgh, Pa.
Eric Zachau, Shaw Crane Works, Manning Maxwell & Moore, Muskegon, Mich.
Sidney Buckley, Niles Bement Pond Co., Philadelphia, Pa.
Norman Farrar, Harnischfeger Corporation, Milwaukee, Wis.
Harry A. Baugh, Shepard Elec. Crane & Hoist Co., Chicago, Ill.
H. P. O'Neil, Milwaukee Elec. Crane & Hoist Co., Milwaukee, Wis.

Transmission Equipment Division

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G. P. Wilson, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
R. V. Bingay, Allis Chalmers Mfg. Co., Pittsburgh, Pa.
G. L. Crosby, Roller Smith Co., New York, N. Y.
P. C. Gunion, ITE Circuit Breaker Co., Philadelphia, Pa.
R. F. Gooding, Condit Elec. Mfg. Corp., Pittsburgh, Pa.
A. F. Alsaker, Delta Star Electric Co., Chicago, Ill.
R. H. Zimmerman, Railway & Ind. Engr. Co., Greensburg, Pa.
J. S. Livingston, Electric Power Equipment Corp., Philadelphia, Pa.
J. J. Mullen, Moloney Electric Co., St. Louis, Mo.
L. B. Gawthorp, Electric Service Supplies Co., Philadelphia, Pa.
Grover W. Lapp, Lapp Insulator Co., LeRoy, N. Y.
W. W. Lewis, General Electric Co., Schenectady, N. Y.
K. A. Hawley, Locke Insulator Co., Baltimore, Md.
G. E. Eckert, R. Thomas & Sons, East Liverpool, Ohio.
A. N. Cartwright, West Penn Power Co., Pittsburgh, Pa.
D. C. Hopper, Duquesne Light Co., Pittsburgh, Pa.
R. L. Baker, Metropolitan Edison Company, Reading, Pa.
J. D. Porter, Aluminum Company of America, Pittsburgh, Pa.
H. E. Ransford, G & W Electric Specialties Co., Pittsburgh, Pa.
J. Leo Scanlon, Schweitzer & Conrad. Buffalo, N. Y.
A. F. Hovey, Standard Underground Cable Co., Pittsburgh, Pa.
J. J. O'Brien, Okonite Company, Chicago, Ill.
J. S. Rashba, Rockbestos Products Corp., Pittsburgh, Pa.

Generating Equipment Division

H. C. Fairbanks, General Electric Company, Schenectady, N. Y.
R. H. Wright, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
W. H. Powell, Allis Chalmers Mfg. Co., Milwaukee, Wis.

Miscellaneous Division

Fittings

C. L. Snyder, Appleton Electric Co., Pittsburgh, Pa.
C. M. Crofoot, Crouse Hinds Co., New York, N. Y.
M. S. Robinson, Erie Malleable Iron Co., Pittsburgh, Pa.
A. E. Tregenza, Chicago Jefferson Fuse & Electric Co., Chicago, Ill.
E. P. Burns, V. V. Fittings Co., Philadelphia, Pa.
T. P. McGinnis, Pyle National Company, Pittsburgh, Pa.

Lubrication

C. O. Nostrum, Keystone Lubricating Co., Philadelphia, Pa.

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R. M. Walker, The Bristol Company, Pittsburgh, Pa.
A. R. Richardson, General Electric Co., Philadelphia, Pa.
G. L. Crosby, Roller Smith Co., New York, N. Y.
W. B. Shirk, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
L. D. Joralemon, Weston Electrical Instrument Co., Philadelphia, Pa.
H. F. Darby, Jr., Jewell Electrical Instrument Co., Philadelphia, Pa.

COMBUSTION ENGINEERING DIVISION

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Walter Flanagan, Special Engr., Carnegie Steel Company, Pittsburgh, Pa.
F. E. Leahy, Asst. to V. Pres., Youngstown Sheet & Tube Co., Youngstown, Ohio.
L. C. Edgar, Chief Engr., Carnegie Steel Company, Braddock, Pa.
W. J. Harper, Fuel Engr., Donner Steel Company, Buffalo, N. Y.
H. C. Seibert, Comb. Engr., Bethlehem Steel Company, Bethlehem, Pa.
J. W. Jones, Steam Engr., Wheeling Steel Corporation, Portsmouth, Ohio.

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F. G. Cutler, Chief Bureau of Steam Engr., T. C. I. & R. R. Co., Ensley, Ala.
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A. J. Boynton, Engr., H. A. Brassert & Co., Chicago, Ill.
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W. E. Bisler, Engr., Combustion Engineering Corp., New York, N. Y.
J. C. Hayes, Engr., Freyn Engineering Co., Chicago, Ill.
Karl L. Landgrebe, Gen. Supt., Tennessee Coal Iron & R. R. Co., Ensley, Ala.
J. W. Jones, Steam Engr., Wheeling Steel Corp., Portsmouth, Ohio.
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W. P. Chandler, Mgr. Open Hearth Div., American Heat Economy Bureau, Pittsburgh, Pa.

E. A. Hawk, Steam Engr. Dept., Tennessee Coal Iron & R. R. Co., Ensley, Ala.
G. R. McDermott, Vice Pres., Chapman Stein Co., Mt. Vernon, Ohio.
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Walter DeFries, Engr., Wellman Seaver Morgan Co., Cleveland, Ohio.
A. G. Witting, Asst. Chief Engr., Illinois Steel Co., Gary, Ind.

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E. H. Younglove, Engr., Johns-Manville, Inc., Chicago, Ill.
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Walter Kennedy, Dist. Mgr., Celite Products Company, Pittsburgh, Pa.

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C. H. Hunt, Chief Engr., Weirton Steel Company, Weirton, W. Va.
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R. S. Shoemaker, Supt. of Maint., American Rolling Mill Co., Middletown, Ohio.
C. L. Baker, Managements Repr., Bethlehem Steel Co., Johnstown, Pa.
L. C. Edgar, Chief Engr., Edgar Thomson Works, Carnegie Steel Company, Braddock, Pa.
Wray Dudley, Elec. Engr., National Tube Co., Pittsburgh, Pa.
F. A. Wiley, Elec. Supt., Wisconsin Steel Co., Chicago, Ill.
F. E. Leahy, Asst. to Vice Pres., Youngstown Sheet & Tube Co., Youngstown, Ohio.

(Note: Balance of Committees will appear in October Issue of Iron & Steel Engineer.)

Items of Interest

Frank W. Cramer, assistant superintendent of the electrical department of the Cambria Plant of the Bethlehem Steel Corporation, has resigned his position with the Cambria Plant to accept the position of chief electrical engineer of the Republic Iron & Steel Company, of Youngstown, O. The many friends of Mr. Cramer are congratulating him upon his elevation to this important position. He assumed his duties at Youngstown on Monday, August 19th.

Mr. Cramer will have supervision of all electrical operation, construction and engineering of the several plants of that corporation.

Mr. Cramer was educated in the public schools and graduated from Johnstown High School in 1910. In 1914 he graduated from Pennsylvania State College and received his Master Degree in Electrical Engineering in 1920. He is a member of the Chi Phi Fraternity and was active in college athletics as well as in high school activities.

He was first associated with the American Gas and Electric Company at Scranton, and then became Testing Engineer of the Pennsylvania Water and Power Company, at Boltwood, Pa., joining the Cambria forces in 1917.

Mr. Cramer has been active in the Association of Iron and Steel Electrical Engineers and has held several offices, being first elected Secretary of the Association and is now the First Vice President.

His papers on Electrical Engineering subjects, concerning steel mills and mining installations, have won for Mr. Cramer recognition throughout the country as one of the outstanding engineers in his line.

The Clark Controller Company of Cleveland, Ohio, announces the appointment of David O. Stewart, 619 Bank of Commerce Building, St. Louis, Mo., as their representative in St. Louis territory.

The Nichols Lintern Co. of Cleveland, Ohio, have recently issued a loose leaf catalogue descriptive of N-L Universal Signal Lanterns for steel mill and factory. Also included are complete descriptions of the Lintern Electro-Magnetic Sander for Overhead Cranes, and N-L Mechanical Sanders for Locomotive Cranes.

A large, well-illustrated book on the subject of Synchronous Motors is now being distributed by the Electric Machinery Mfg. Company of Minneapolis, specialists in the manufacture of this type of electrical equipment. The company has felt for a number of years that the books already in circulation were far too technical for executives and plant managers, while there was nothing available on the application of these motors.

"The Most Efficient Drive in Industry," as the new book is called, contains 56 pages and 85 illustrations. The advantages of the Synchronous Motor in comparison with other types, the theory of its operation, and its development to present high efficiency are well covered, while the last half of the book is devoted to scores of applications.

The refrigerating, pulp and paper, rubber, cement and iron and steel industries are given special attention, while the brass and copper, coke and gas, lumber, flour, mining and smelting fields receive valuable discussion. Offices of the Electric Machinery Mfg. Company in various large cities now have a supply or copies can be had free by writing to the main office at Minneapolis.

Stanley Grand Girard, recently of the Republic Iron & Steel Company of Youngstown, Ohio, in the capacity of Assistant Electrical Engineer, has just been appointed Electrical Engineer for the Sharon Steel Hoop Company at Sharon, Pa.

The American Heat Economy Bureau, Inc. has recently received an order from the Carnegie Steel Company to equip one of the heating furnaces at their Duquesne Works with Automatic Control equipment for regulating the combustion of fuel in the furnace. The desirability of such control has been well shown by a recent installation on a slab heating furnace.

The heated slabs discharged from the furnace have a very thin uniform scale which readily breaks off at the rolls; while the flame in the furnace is simply a haze at the rear end. Serious difficulty had previously been encountered in operating the furnace. At some periods so much gas was fired that it burned at the stack or else excessive scaling occurred, impairing the quality of the finished product. The automatic control admits only the desired amount of air to the furnace for the fuel fired and maintains this condition for all rates of firing. Under such uniform conditions, the scale loss on heating furnaces is reduced 50 per cent or more, while the fuel consumption is maintained at a minimum, dependent on the furnace design and the character of the steel heated.

The Condit Electrical Mfg. Corporation have placed on the market a new, manually operated manhole oil circuit breaker known as the type M-9, especially designed for underground distribution for all voltages up to 7500.

This breaker is of sturdy, water-tight construction. A strong, rugged frame is used with reinforcing ribs at selected points affording a rigid foundation for the mechanism contact, studs and bushings. The frame is arranged on two sides for either single or multi-conductor cable sleeves.

The tank is of strong, rectangular construction securely bolted at many points to the underside of the frame. Gaskets are provided at all joints, affording water-tight construction.

The type M-9 is furnished for automatic or non-automatic operation. For automatic operation a bushing type current transformer and a trip coil per pole are furnished.

The breaker is furnished three pole, for 400, 600 and 800 ampere capacity at 7500 volts with an estimated interrupting capacity of 3000 amperes at 7500 volts.